MODERN PLASTICS

OCTOBER 1939 VOLUME 17 NUMBER 2

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NOVEMBER

Winners in Modern Plastics' Fourth Annual Competition will be pictured and described in our November issue and readers are cordially invited to visit the 26th floor of the Chanin Building, 122 East 42nd Street, New York, N. Y., where all entries are on exhibit until December. There will be an important article in the Technical Section of the November issue on the subject of Cold Flow, written by C. H. Penning and L. W. A. Meyer of the Tennessee Eastman Corp. A discussion of the possibilities of Crystaplem, the new French method of molding cellulose acetate in plaster molds, will also be included in this forthcoming issue.

MODERN PLASTICS

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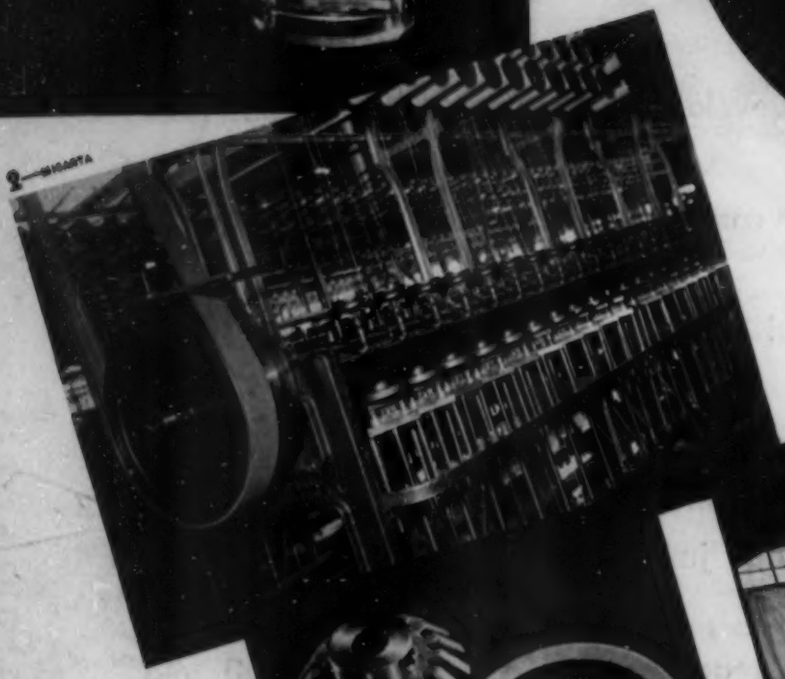
Cover this month mahogany PARKWOOD-TEXTOLITE, made by General Electric Company

PRODUCT DEVELOPMENT

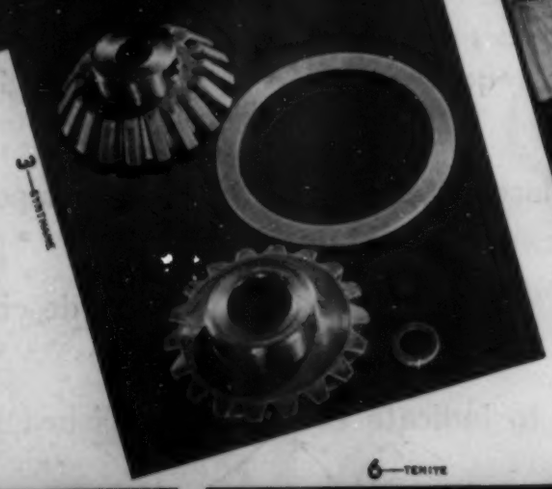
Product Development in which plastic materials contribute conspicuous characteristics toward successful and satisfying service has reached an advanced position in our daily lives. In an effort to point out just how broadly these materials serve our requirements, both in industrial and commonplace applications, we have grouped the following pictorial pages with brief descriptive comment to indicate the well established trend.

INDUSTRY

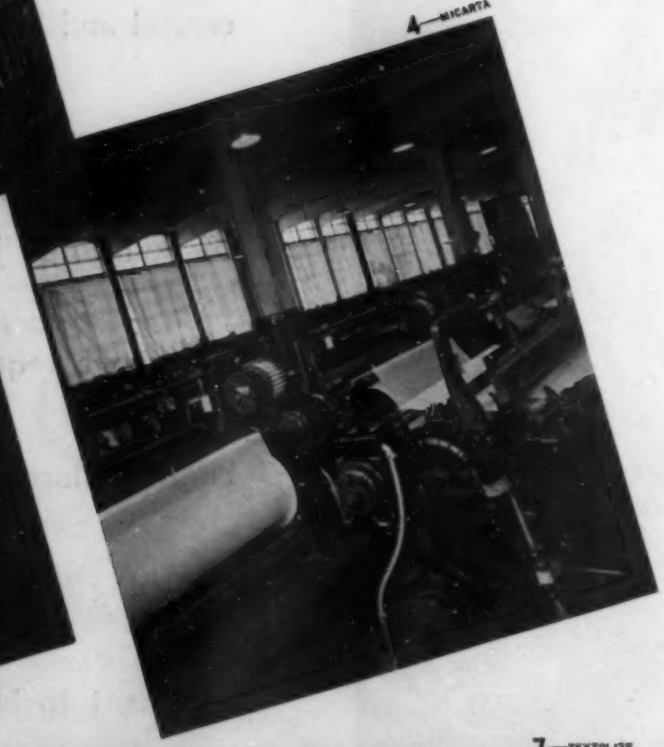
1—TENITE



2—MICARTA



3—SYNTHANE



4—MICARTA

5—CUBEX

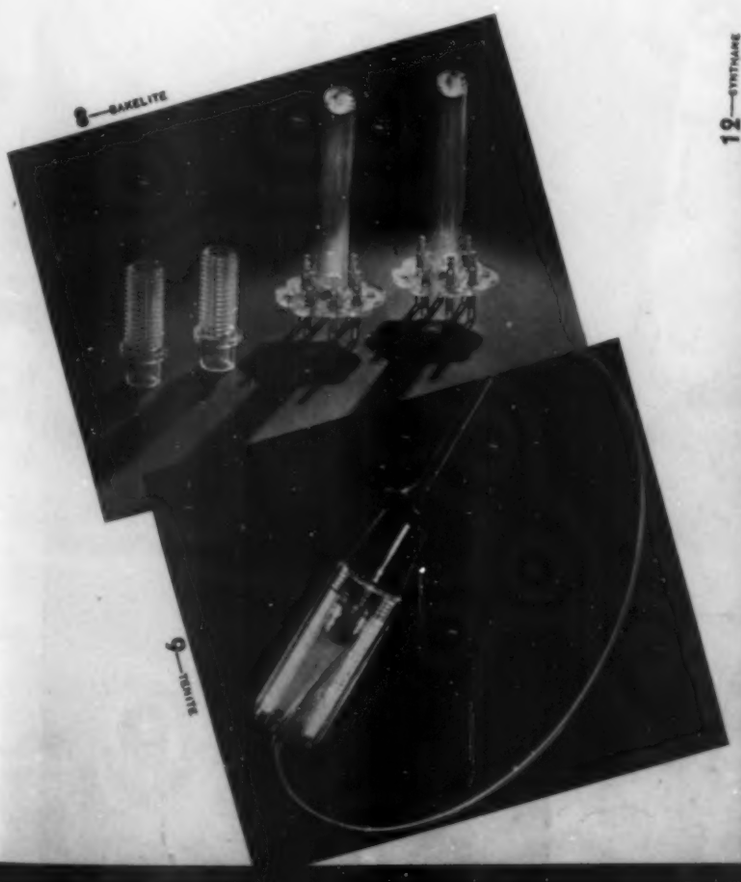
6—TENITE

7—TEXTOLITE

INDUSTRY, NATURALLY, CONSUMES A GREAT quantity of plastic products as well as producing them for consumer use. Laminated plastics, because of their ability to resist wear, abrasion, moisture, etc., are used as gears (3, 7). They are quiet in operation, may be lubricated with water, and possess many attributes which recommend them to such service. Textile machinery (2, 4) employs such materials where great strength and a perfectly smooth surface are required. Plastic materials are also used as extremely efficient insulation (8, molded; 12, laminated). Transparency and resistance to grease and oils, make certain plastics highly desirable for electrical (9) and mechanical (1, 6, 11) casings and handles. Small machine and other tools (5, 10) employ plastics as housings because the material serves as insulation and provides a smooth, easy and lasting grip of excellent appearance.

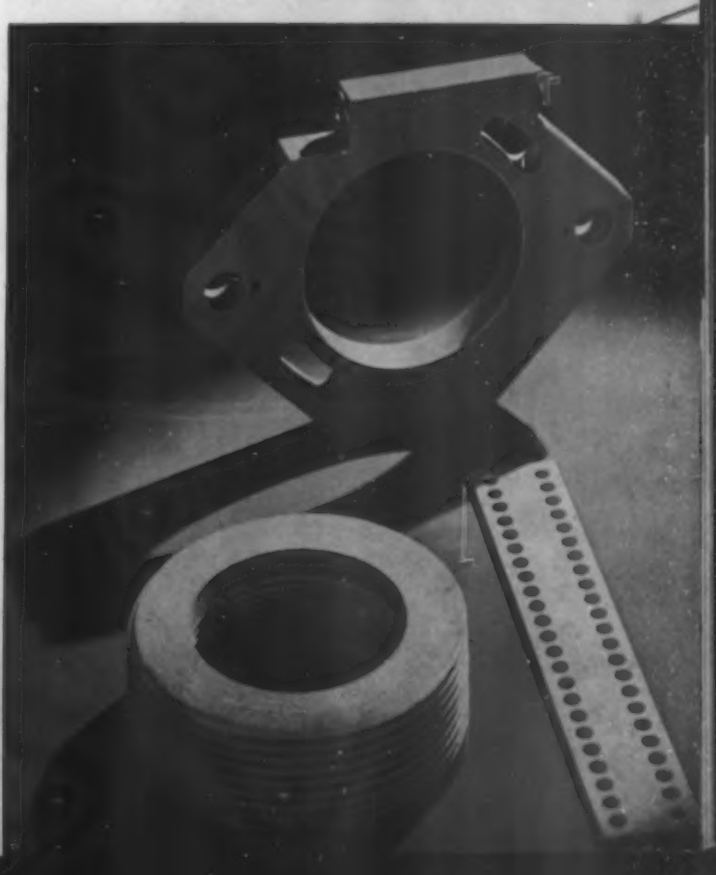
10—BAKELITE

11—TENITE



8—BAKELITE

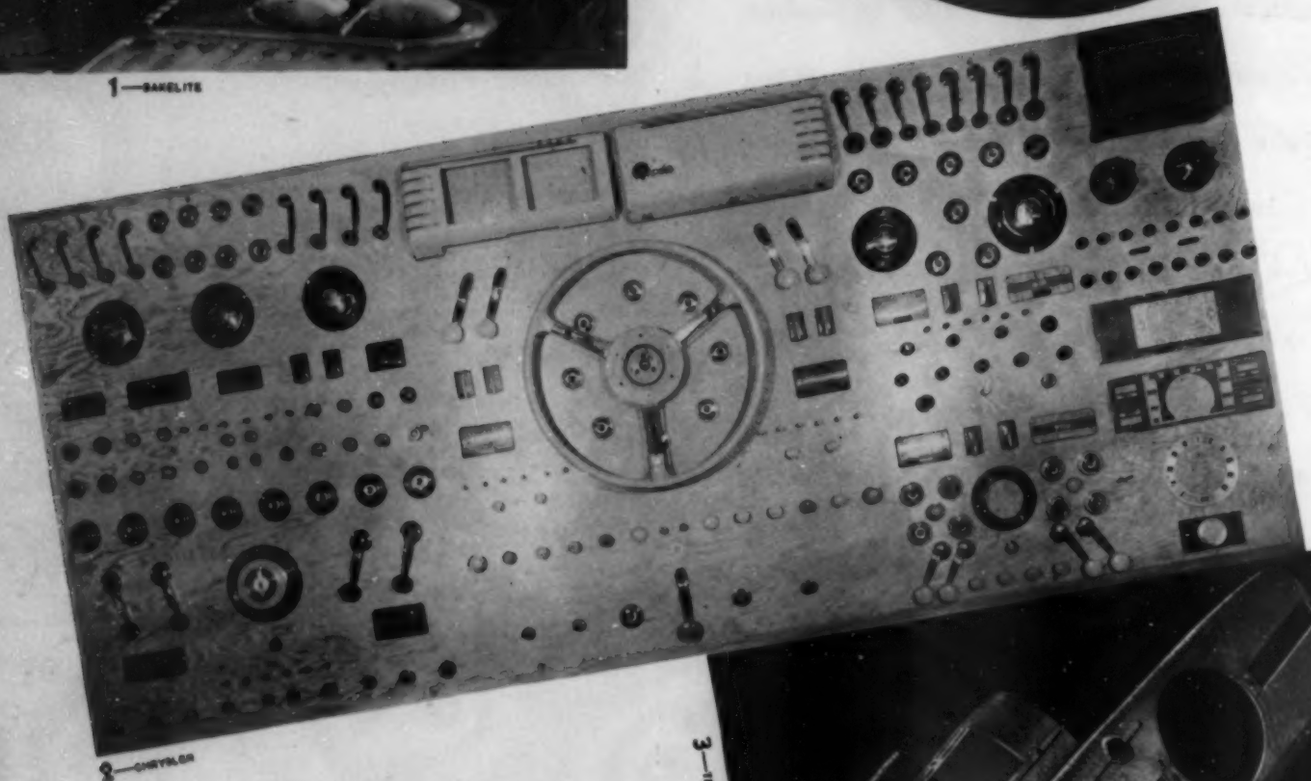
9—TENITE



12—SYNTHANE

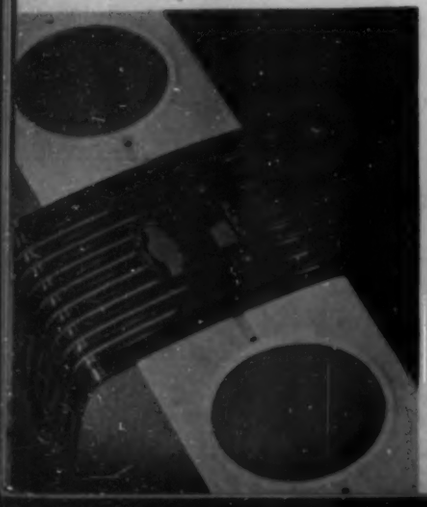
AUTOMOTIVE

1—BAKELITE



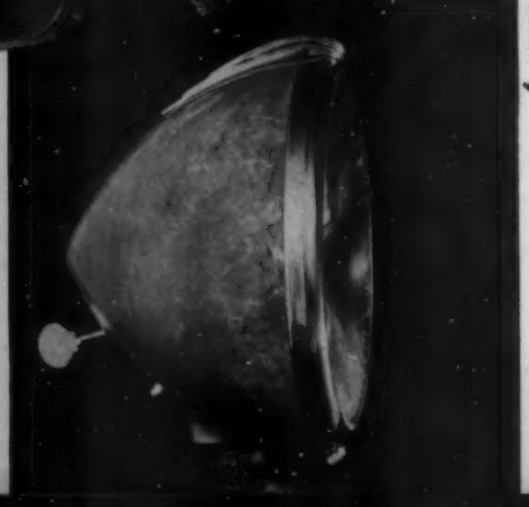
2—CHEVROLET

3—TENITE



4—TENITE

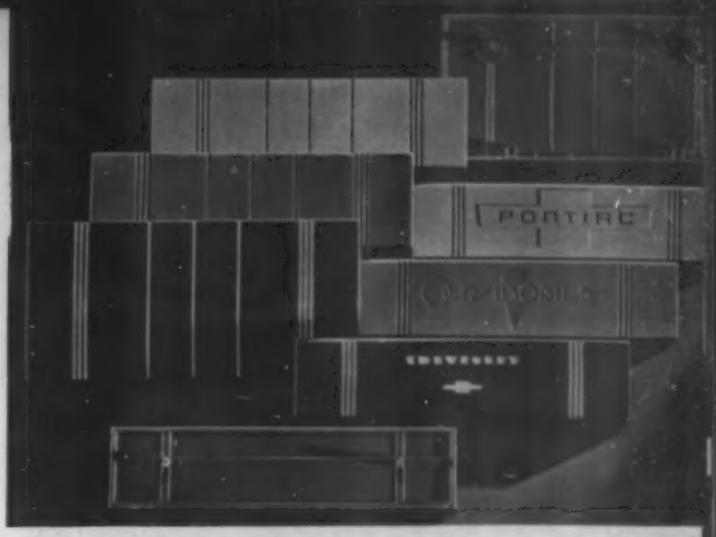
5—TENITE



6—LUMARITH

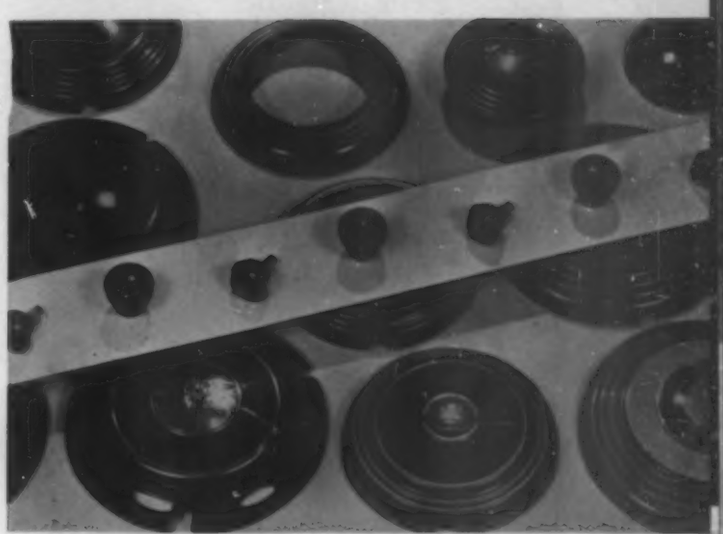
SINCE THE TURN OF THE CENTURY WHEN celluloid wind and rain curtains first darkened the interior of the horseless carriage, plastics in one form or another have found increasing usage in the manufacture of motor cars. Through laminated gears, they provide noiseless and trouble-free timing mechanism. And through modern methods of injection and compression molding and automatic finishing operations, they contribute to the electrical (10), mechanical (1, 2, 5, 6, 8), and decorative (3, 4, 7, 9, 11) perfection of the present-day automobile. Chrysler Corp., a leading exponent in the use of plastics in automotive manufacture, assembles visual displays (2) of the various plastic parts for each of the cars it makes, for engineering and sales reference in the home office. That plastics are no longer considered tawdry as automotive decoration is evidenced by the Packard instrument panel (3) used on a special show car for the World's Fair, which also appears on production models in the higher brackets of retail prices.

11—TENITE



10—DURET

9—DURET



8—TENITE

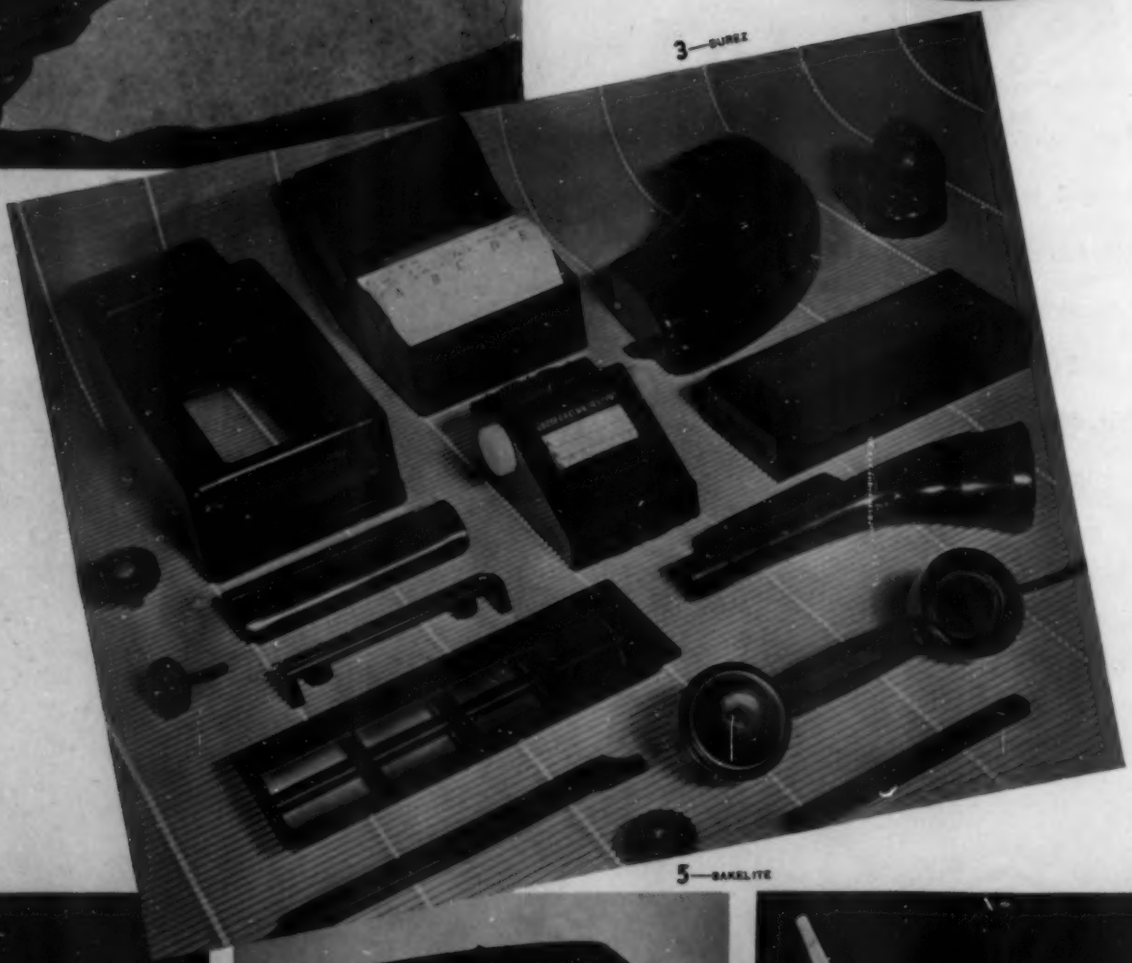
7—TENITE

IN THE OFFICE

1—PLASTEX

2—PLASTEX

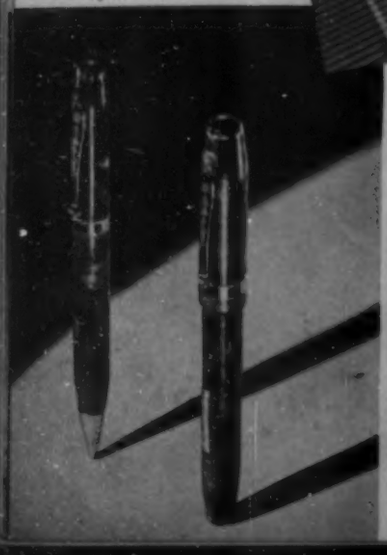
3—PLASTEX



4—TENITE

5—BAKELITE

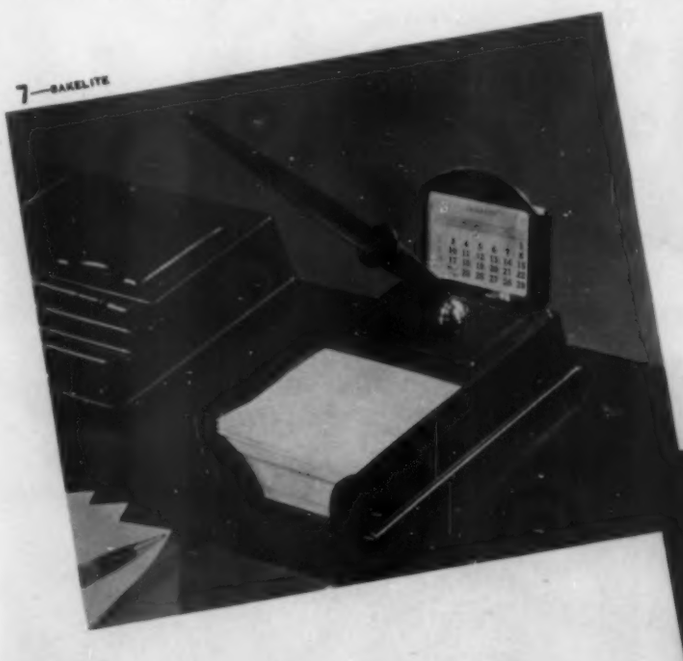
6—TENITE



FOUNTAIN PENS (4, 6), CARD INDEX BOXES, dictaphone and typewriter parts (3), calendars, ash-trays and desk memoranda boxes (7) of plastic material are familiar equipment in any modern office. Telephones, of course, are made of molded phenolics and acetates—have been for a long time. Typewriter keys and adding machine keys (9) are invariably made of plastics, usually injection molded of cellulose acetate compound. More recently, however, business machines (10) have appeared in business-like plastic housings which give them a smart, efficient appearance with a surface that remains unscratched through many years of constant service. Likewise, sales registers (1, 8) have been lightened in weight as well as in color through the adoption of a molded plastic case. Thermometers and humidity indicators (5) are more in keeping with modern affairs in a smart housing of plastic material. Even office chair legs (2) enjoy the protective benefits of a molded scuff plate, and casters are frequently molded from phenolic materials.

10—DUREZ

9—TENITE



7—BAKELITE

8—PLASKON

IN THE HOME

1—DURES CASE—TENITE GRILLE

2—DURES

3—DURANTO

4—DURES

5—TEXTOLITE

6—PLASKON

THERE ARE MANY PLACES IN THE HOME where plastics have become indispensable. They have replaced other materials which rendered less permanent service and at the same time, they have improved the appearance of commonplace things by providing cheerful color and a lasting surface which doesn't chip, dent, nor wear off. Radios (1), for example, with reception qualities of higher priced sets, have been made available at low cost because their housings are molded from plastic materials. Ash-trays (2), brushes of every sort (3, 10), lamp shades and reflectors (4, 5), clocks (6), colored telephones (11), sewing baskets (8), and other transparent containers for hats, gloves, etc., door knobs (9) and cabinet hardware (7) all benefit through the continued research and perfection of plastic molding compounds of one type or another. The Hammond organ (12) employs plastics for both light and dark keys. They do not yellow with age. Even the panels of the instrument case are bonded for permanence with phenolic resin film.

12—BAKELITE

11—TENITE

7—TENITE

10—TENITE

8—PLASTACELE

9—TENITE

IN THE HOME

1—BAKELITE

2—BAKELITE

3—BAKELITE

4—DURES

5—THERMOPLAX

6—PLAXILOX

THE JOY OF LIVING AND ENTERTAINING IN this modern age has been accented by the introduction of more pleasing and useful utensils. Industrial designers, with a flair for hospitality and an appreciation of drama in presentation, have used modern plastics for utility as well as to obtain their decorative ends. Cast resins, for example, are commonly used as decorative handles on coffee sets (1), tableware (3) and carving sets (12). They are also used on the strictly utilitarian items in Fig. 7. These are machined from solid rods or semi-shaped pieces which are simple and economical to manufacture. Molded handles for pots and pans (2), transparent coffee makers (6) and teakettles (8) are made of heat-resisting materials which look well and last a long time. The coffee maker (5) is equipped with cold molded handles and knobs—the most heat-resistant of all plastic materials. Coasters (4), napkin holders (10, 11) and the head of your Sparklets siphon (9) are plastic as well.

INTERIORS

1—MICARTA

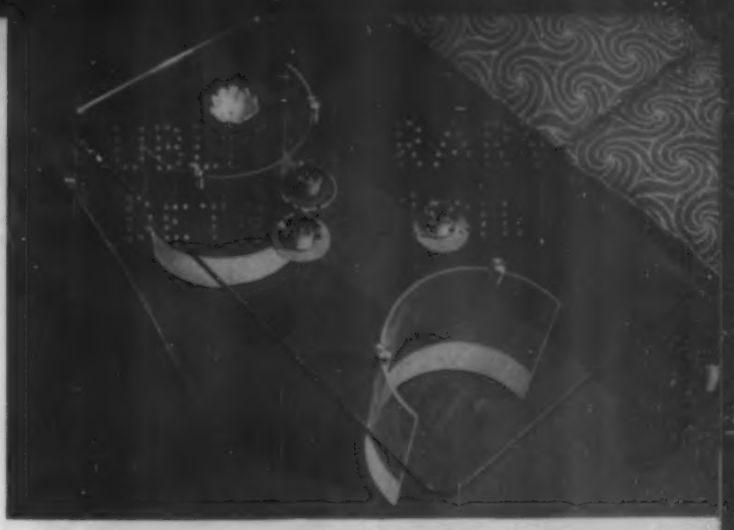
2—MICARTA

5—MICARTA

3—FORMICA REALWOOD

4—FORMICA REALWOOD

BAR AND TABLE TOPS (1), AND WINDOW SILLS (5) have long been made with laminated materials because they withstand continuous cleaning, resist food and beverage stains, and can be made impervious to cigaret burns. Recently, the vogue of laminating rare woods has advanced in favor with interior designers as well as with architects because in the process of lamination with plastic materials, these woods achieve permanent protection for their decorative surfaces. For example, the room in Fig. 2 has bisque paneled walls with curly maple paneling below—all laminated. Table and bureau tops in the Royal Suite of the Hotel Vancouver at Vancouver, B. C. (3, 4, 6) are laminated real wood. Lamps, of course, are using plastics more and more. Some are all plastic (8) including the shades; others use woven wood laminated with cellulose acetate or urea (7) for a shade. The clear acrylic resins are like putty in the hands of an experienced decorator. He bends huge sheets into delightful coffee tables (9, 10), combining these understructures with glass tops or tops of the same plastic material.



10—PLEXIGLAS

9—PLEXIGLAS

8—LUMARITH

6—FORMICA REALWOOD

7—PANNOG PLASTACEL

IN SPORTS

1—TENITE

2—BAKELITE

3—TENITE

4—DUREZ

5—BAKELITE

6—BEETLE

PLASTICS ARE GAME ENOUGH TO ENTER into most sports and like all champions, after they have proved their worth, have achieved universal approval. Their most recent entry into sports is in the form of a gun stock (1) where cellulose acetate material, specially mottled or burled to look like walnut, provides a sure and sturdy grip of exceptional resilience and long wear. Hunting knife handles (2), trigger guards and other rifle parts (3), and golf ferrules (10) indicate their varied progress in the field of sports. Fishing equipment has long employed plastic materials, both acetate and phenolics, for reels (7), spoons, bobs (9), synthetic bait and (8) transparent boxes for flies and hooks. Cameras (4, 5, 6) and sports glasses (11) have been materially improved through the use of plastic materials. Helmets for ball players (12) have recently been added to those already in use by miners, firemen and police.

12—BAKELITE

11—BAKELITE

10—TEXTOLITE

7—DUREZ

8—TENITE

9—BOAKANTO

1—BAKELITE

ETCETERA

2—BAKELITE

AND SO IT GOES—THROUGH EVERY ACTIVITY in our normal lives we encounter plastics. We find them serving us more efficiently than the materials they have replaced. We call them composition, artificial this or that—but whatever their complicated chemical makeups may be, they are all plastics and you will find them explained in greater detail throughout this book. As a last glimpse of miscellaneous uses we picture a pipe (1) with stem and bowl of plastics, cigaret holders (2), swagger sticks of colorful cast resin (3), vanities (4), combination brush and comb (5) in a transparent case, a molded spectacle case (7) and finally—tableware (6) for aristocratic pups.

3—BAKELITE

4—BONDAPIPE

5—PLASTACELE

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PLASTICS PROPERTIES CHART—Opposite 186

Model 166 Martin Bomber equipped with transparent sheet Plexiglas cockpit enclosure. The material, which weighs less than half as much as glass, allows perfect vision in all directions yet will not shatter in a crash or forced landing

ACRYLIC RESINS

by D. S. FREDERICK*

THE RESINOUS PRODUCTS OBTAINED BY THE polymerization of the monomeric derivatives of acrylic acid are known as the acrylic resins. This group includes acrylic and methacrylic acids, their esters, amides, salts, halides, and nitriles. From a commercial standpoint the esters are of most importance at the present time. Several investigators experimented with acrylic acid derivatives prior to 1900, but the industrial development of these resins was due mainly to the research of Dr. Otto Röhm, of Darmstadt, Germany, whose original publication on this subject appeared in 1901. In 1931 acrylic resins were first made available in commercial quantities in this country.

Chemistry of their formation

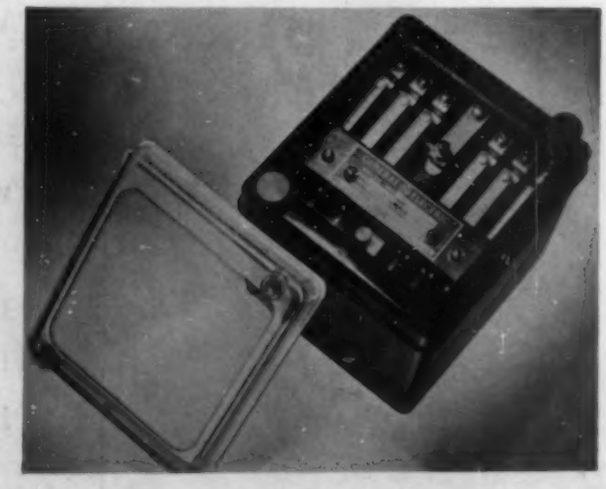
The structural formula of acrylic acid is $CH_2{=}CH{-}COOH$ and that of its widely used alpha-methyl derivative (methacrylic acid) is $CH_2{=}C(CH_3){-}COOH$. The reactions involved in the synthesis of acrylic acid esters, starting with ethylene chlorohydrin, may be represented as follows:

1. $CH_2OH.CH_2Cl + NaCN \rightarrow CH_2OH.CH_2CN + NaCl$

2. $CH_2OH.CH_2CN + ROH + H_2SO_4 \rightarrow CH_2{=}CH{-}COOR + NH_4HSO_4$

Esters of methacrylic acid are conveniently prepared by converting acetone cyanohydrin into alpha-hydroxyisobutyric acid esters and dehydrating the hydroxy ester. The esters of both acrylic and methacrylic acids polymerize under the influence of heat, light, oxygen, and oxygen-yielding substances, for example, sodium peroxide, hydrogen peroxide, and benzoyl peroxide. The

The cover on this HFA Relay is molded from transparent Crystalite by General Electric Co. to provide a clear view of the interior mechanism



* Röhm & Haas Co.

mechanism of the polymerization of polyacrylates is believed to be similar to that of other compounds containing vinyl groups. The usual conception of the structure of these resins is that they exist as chains of various lengths formed by the linking together of the original monomeric molecules.

General characteristics

Acrylic resins varying from soft, sticky semi-liquids to hard, tough, thermoplastic solids can be prepared without the use of plasticizers. Hence the acrylic resins are not handicapped by the disadvantages which the customary use of a plasticizer introduces.

The compatibility of these resins with other synthetic polymers and with natural resins is limited. Many of the acrylic polymers are rather unexpectedly incompatible with each other. However, desirable variations in the properties of these resins can be achieved by copolymerization of the various monomers.

Acrylic resins as binders for wood, metals, textiles, rubber, glass, and other materials offer the advantages of freedom from bacterial and fungous deterioration, and afford the possibility of a colorless transparent bond. The elasticity and extensibility of the acrylic adhesives permit their use where the bonded assemblies are subject to flexure and elongation.

In the textile field, aqueous dispersions of the acrylic polymers are used as permanent finishes, stiffening and increasing the tensile strength and wear resistance of the impregnated fabrics. They do not require baking, are wash fast, and give stiffness and shearness to a fabric. The acrylic resins are also widely used as coatings for metal and finishes for leather.

The most important of the acrylic resins used in making cast sheets is polymethyl methacrylate. The aircraft industry has found these sheets particularly well adapted to its requirements, because of their lightness, weathering resistance, and clarity, and therefore employs them in landing light covers, gun turrets, and cockpit enclosures in addition to the more common windshield and window applications.

As the basic resin is crystal clear, it is possible by adding pigments and dyes to produce compression and injection molding powders having any shade or color and any degree of opacity.

Developments during 1939

The use of these resins expanded into five relatively new fields during the past year; namely, lenses, dentures, highway reflectors, signs, and displays.

Methyl methacrylate is probably the nearest approach to organic glass thus far developed. Its optical properties make it suitable for spectacle lenses, camera lenses, magnifying glasses, and protective goggles. Spectacle lenses are now being made to prescription by molding. It is estimated that 900 molds will supply the requirements of 98 percent of the prescriptions.

A denture material made of this type of resin has met with a very favorable reception in the dental profession. In addition to being readily pigmented to simulate the color of the mouth tissues and possessing the necessary toughness and resistance to water, acids, and alkalies, the temperature range in which it can be satisfactorily formed in the plaster molds employed in the dental laboratories is not as restricted as it is for the other synthetic resins in current use for the same purpose.

A new and promising application of the acrylic resins is as molded reflectors in a system of indirect highway lighting. The reflectors are pressed from colorless transparent methyl methacrylate resin and are $1^{5}/_{8}$ inches in diameter. They are assembled in a pressed metal housing to form a double facing marker which is snap-locked

Acrylic resins are sometimes cast, sometimes molded by compression or injection. The fascinating walking-sticks at the left are cast Lucite fabricated by Ortho Plastic Novelties, Inc. The transparent cover on the Berg-Johnson box (right) is molded Lucite

to the top of an angle iron post. The motorist provides his own light from his headlights which strikes the reflectors and is returned as a narrow beam of brilliant illumination from relatively long distances.

The transparency of the acrylic resins makes possible the phenomenon of edge-lighting; that is, light entering one edge will leave the opposite edge almost undiminished—even though the material is bent or curved—unless the surface is carved or sand-blasted. This property has found application in the sign industry where designers have found they can obtain novel effects by heating and shaping letters from the thermoplastic sheets or bars, and then lighting from one edge. When the surfaces of the letters are sand-blasted, they stand out in glowing relief. A different effect may be obtained by carving a design on the surface of a sheet illuminated from one edge. The design is brightly lit, the surface almost invisible.

Since sheets, bars, and rods may be machined to various shapes and bent when heated into any desired curve, the material has been used in display fixtures which, because of their transparency, can show merchandise to good advantage without detracting from it. In the display field it has also been used in fabricating a transparent automobile which showed the motor and chassis construction, a transparent cabinet for a demonstration television set, and a transparent model house which made details of "hidden" plumbing easily visible.

Methods of fabrication

Casting: Monomers are mobile liquids which polymerize upon heating in the presence of a catalyst.

Molding: Compression molding conditions are 285 deg. to 360 deg. F. and 1500 to 5000 lbs. per sq. in. The resins are thermoplastic and hence require chilling in the mold. Injection molding conditions are 325 deg. to 425 deg. F. and 3000 to 30,000 lbs. per sq. inch.

Forming: Sheets, bars, and rods may be shaped to specifications at temperatures of about 180 deg. to 250 deg. F., using simple forms.

Forms available

Cast sheets up to 45 in. by 65 in. in plane and formed shapes
Compression molding powder
Injection molding powder
Cast rods
Granular solids
Solutions in organic solvents
Aqueous emulsions

Typical applications

Airplane windshields
Decorative articles
Lenses
Dentures
Illuminated signs
Illuminating accessories
Laminated glass interlayer
Protective coatings
Adhesives
Displays

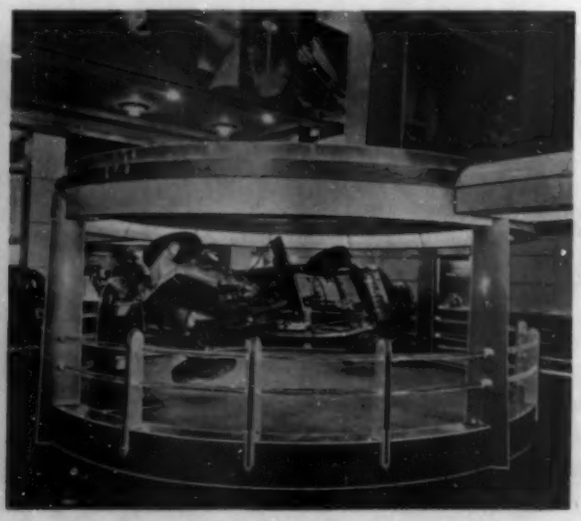
Outstanding properties

Superior transparency
Permanence of dimensions
Edge-lighting
Colorability
Water resistance
Rigidity
Weather resistance

Trade names

Acryloid, Crystalite, Lucite, Plexiglas

Spectacular exhibits in which acrylic plastics furnish the dramatic note are in evidence at the New York World's Fair. For example: This Pontiac car (left) with a transparent Plexiglas body through which all of the car's features may be clearly seen. The enclosing rail for the Chevrolet display at the last Automobile Show (right) is cast Lucite rod, 1½ in. thick, lighted by concealed bulbs in the upright columns



The Golden Gate Bridge, that stretches across San Francisco Harbor, is finished with an alkyd resin pigmented with basic lead chromate

ALKYD RESINS

by A. G. HOVEY*

THE ALKYD RESINS HAVE, AS PRINCIPAL REACTING ingredients, polyhydric alcohols and polybasic acids. The prefix "AL-" from the word "alcohol," and the suffix "-CID" from the word "acid," through an evolutionary process induced by simpler spelling and more euphonious sounding, are the roots of the word *Alkyd*. The name includes the unmodified resins as well as those modified with fatty acids of vegetable oils, with rosin, and with other synthetic resins. The principal alkyd resins on the market are those of the drying type used as complete synthetic finish vehicles all by themselves, and the resins used in lacquers with cellulose derivatives which usually are of the non-drying type. Berzelius reported a resin from tartaric acid and glycerol in 1847, but it was not until 1901 that Watson Smith, seeking a dye, discovered that a resin resulted from fusing phthalic anhydride and glycerol. Modified alkyd resins consisting of mixed esters of rosin, vegetable oil fatty acids, and plasticizing oils such as castor oil, interesterified with polyhydric alcohols and polybasic acids, were disclosed by Arsem, Friedberg, Howell, and Dawson, during 1912–1915. The enormous decrease in cost of phthalic anhydride by the process of Gibbs and Conover of the U. S. Department of Agriculture, who dedicated the patent to the people of the United States in 1918, made possible the commercial success of the alkyd resins. The alkyds modified with phenol-formaldehyde condensation products, as described by Dr. Herbert Hoenel, were among the first really commercially successful products because of the improved water-resistance.

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Chemical reactions involved

The reactions of glycerol and of ethylene glycol with phthalic anhydride, as early shown by Kienle and the author, involve principally esterification, and may be represented according to a general reaction:

$$R(COOH)_m + R'(OH)_n \rightleftharpoons \underset{\text{(resin)}}{R(COO)_mR'} + \underset{\text{(water vapor)}}{n\ H_2O}$$

If the water vapor is allowed to escape, the equilibrium shifts to the right and the reaction proceeds. Functionality of the reacting ingredients plays an all-important part in determining the properties of the resinous product; the greater the number of reactive points on each molecule that may be seized upon by reactive groups of other molecules, the greater the chance of formation of complex structures, and of gelation. The introduction of modifying monobasic fatty or resinous acids or of monohydric alcohols cuts down the number of reactive functional groups which are available for forming cross-linkages between linear polymeric structures; this decreases the chances of gelation, and introduces different solubility characteristics.

General characteristics

Alkyd resins may be prepared in various ranges of consistency from oily air-drying or non-drying liquid resins

of low viscosity right up to high melting point, brittle resins which are used in sanding lacquers and sealers for furniture finishes. The introduction of modifying ingredients into alkyd resins gives them an internal plasticization, because the plasticizing structure is formed as an integral part of the resin molecules "in situ" and may eliminate to a large extent the disadvantages of the use of an ordinary chemical plasticizer, which may be lost by evaporation, oxidation, migration, or absorption.

The compatibility of alkyd resins with other materials commonly used in the paint, varnish, lacquer, and printing ink industries is exceedingly great. There are very few materials with which alkyd resins cannot be made miscible upon judicious formulation. Co-condensation of alkyd resins with other types of resins, such as the phenol-aldehyde and the urea-aldehyde resins, produces many desirable changes in properties, the phenolic modification introducing greater water-resistance, and the urea modification inducing great hardness without sacrifice in color.

Alkyd resins as coatings for metal, wood, and general materials of construction have the advantages of high gloss, good adhesion, and resistance to weathering on exterior exposure. On account of their well-known good properties as long-life protection of the surface, the alkyd resin is king of all the coating materials of the present day, being used in primers, surfacers, colored enamels, white high-baking refrigerator enamels, air-drying brushing enamels, particularly where color is important, in furniture finishes, and in water emulsion paints. The universal satisfaction obtained where protection and retention of original good appearance is desired, together with reasonable cost, has earned for alkyds their enviable place in the finishing industry.

Alkyd resins, up to the present time, have not been important in molding plastics principally because of the fact that their flow under pressure has been too much instead of too little, and the fact that hot strength of such molded compounds is decidedly inferior. However, it is expected that alkyd resins will eventually play an important part in the molded plastics industry.

Developments during 1939

Aside from the general improvement which takes place year by year in the multifold uses for which alkyd resins are already in use, some of the main new developments of alkyd resins during the year 1939 are, briefly: faster printing inks, better exterior white brushing enamels, alkyd resin emulsion paints, and super-white enamels in combination of the alkyd with urea-formaldehyde condensation products.

The printing industry demands vehicles which will not become sticky on the rolls, but which will set immediately when on the object to be printed. Many new alkyd resins have assisted greatly in solving this problem of the printers.

Vehicles for better white brushing enamels for exterior purposes have been developed which have high gloss, durability, and unsurpassed color retention.

Alkyd resins in emulsion paints are believed to be one of the outstanding developments in coating materials. Water paints of drying oils have been known for centuries, and so have casein paints. Furthermore, the durability of the alkyd resins is accepted as the standard for any coating. But it is only very recently that the natural outcome has been fulfilled by the emulsification of phthalic-glyceride-linseed esters into an alkaline aqueous phase which has replaced the linseed glyceride ester which occurs in nature. The result is a fast-drying water paint which has exterior durability and retention of good appearance at a very reasonable cost with elimination of fire hazard by eliminating the solvent. Furthermore, it is not necessary to wait for wood, brick, or concrete to dry out thoroughly after a rainstorm before painting them.

Glossy, super-hard, super-grease-resistant, white refrigerator finishes, obtained by short baking schedules, are the result of successful combinations of urea-formaldehyde resins with the alkyd resins. There is a versatility of the form of alkyd resins available; there is a resin for practically every type of coating application.

Forms available

Oily, viscous, drying-type resins.
Oily, viscous, non-drying-type resin-plasticizers.
Air-drying resins in solution form.
Non-drying resins in solution form.
Soft, sticky resins without solvent.
Hard, brittle resins without solvent.
Resins in aqueous emulsion form.

Methods of application

Spraying
Dipping
Roll coating
Brushing
Hot melt application

Typical applications

Printing ink
Trim and trellis paint
Resinous plasticizers for other materials
Sanding lacquers
Furniture finishes
Original finish for automobiles and tractors
Automotive refinishing
Metal primers and surfacers
Tin decorating enamels
Wrinkle finishes
Water emulsion paints

Outstanding properties

Long retention of initial good appearance.
Long exterior exposure life on weathering.
Ease of application.
Solubility in relatively cheap solvents.
High gloss.
Adhesion to metal.
Quick drying schedule or baking schedule.

Trade names

Amberlac, Aquaplex, Beckosol, Dulux, Duraplex, Esterol, Glyptal, Lewisol, Makalot, Mirasol, Paraplex, Rauzone, Rezyl, Teglac.

The major use of casein plastics is for buttons, buckles and trimmings, but the material is frequently fabricated into colorful and lustrous utility items such as these by the A. J. & K. Co., Incorporated

CASEIN PLASTICS

THE MAIN FACT OF GENERAL INTEREST CONcerning this type of plastic is the source of the chief raw material, namely, milk. The casein, which is the protein portion of milk, can be precipitated in several ways, such as by heating or the addition of acids, but for the manufacture of plastics, casein obtained by the action of the enzyme rennet, is preferred. The early development of this plastic took place in Germany and can be traced back to the discovery reported in 1900 in U. S. Patent 646,844 by Spitteler and Krische that formaldehyde converts casein into a tough, insoluble, horn-like mass. Shortly afterward they adopted for their product the trade name "Galalith" from the Greek, meaning "milk stone," and this word has to some extent been used as a general descriptive term for all casein plastics, regardless of manufacturing source.

Chemistry of their production

Casein belongs to the group of organic compounds known as proteins which are probably formed by the condensation of amino acids with the elimination of water. The essential linkage is of the peptide type, —NH—CO—. Many different amino acids have been isolated from the hydrolytic decomposition products of casein. The hardening process is analogous to the tanning of leather which is also a protein material. It has been suggested that the reaction with formaldehyde is one of condensation of the free amino groups with the aldehyde with elimination of water:

$$\begin{matrix} -NH_2 \\ \\ -NH_2 \end{matrix} + CH_2O \longrightarrow \begin{matrix} -NH \\ \diagdown \\ CH_2 \\ \diagup \\ -NH \end{matrix} + H_2O$$

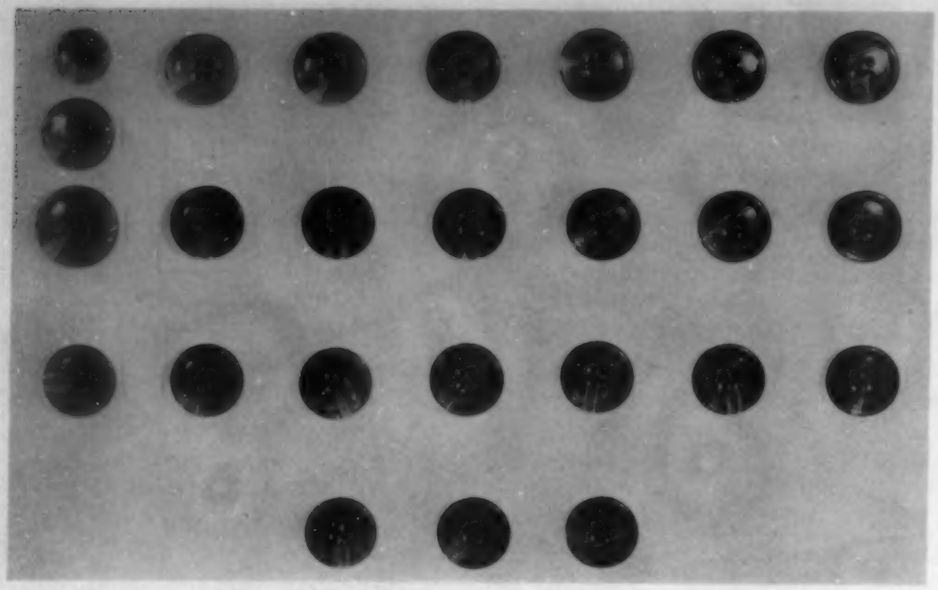
or

$$-NH_2 + CH_2O \longrightarrow -N=CH_2 + H_2O.$$

Other possibilities for the course of this reaction exist and the nature of the hardening process is still a matter of considerable speculation.

Manufacturing process

The following outline of the manufacture of casein plastics gives a general picture of their preparation, but no attempt is made to include details regarding the necessary precautions and chemical control that are required. The rennet casein is ordinarily supplied to the trade in the granular form as it comes from the drier. This is ground in a mill with corrugated rolls, such as are used in flour mills, or by impact pulverizers to pass a 40-mesh sieve with only a small percentage of fine powder which will pass through a 100-mesh sieve. It is then thoroughly kneaded in a dough mixer with about 40 percent of water and with coloring materials. The greater the proportion of water the softer the plastic and the greater the shrinkage on finishing. After admixture with water, the plastic must be carried through the next steps without delay. It is fed into a heated cylinder press fitted with a rotating screw and a nozzle with a bore of the desired size for the production of tubes and rods. The strength of the plastic is to a large extent dependent upon the mechanical working and macromolecular orientation which takes place during this operation. Sheets are ordinarily made by placing freshly extruded rods in frames of the desired size (usually 16 by 20 inches) and thickness, and pressing in heated hydraulic presses. Slicing sheets of the desired thickness from blocks of the soft plastic is an alternative method but is not in general use. The sheets, rods, and tubes of casein plastic so



The George Morrell Corp. makes millions of casein buttons every month and has introduced the Delorme method of obtaining uniform striations, and controls the patents for this process in the United States and Canada

formed are hardened and converted into a compound no longer subject to putrefaction, by immersion in aqueous formaldehyde solution of 4 to 5 percent concentration for periods varying from 1 week to 6 months depending upon the thickness. Excess moisture and formaldehyde is then allowed to evaporate slowly to minimize formation of strains in the material with consequent cracking.

The time required for the complete formalization treatment may run considerably in excess of six months. A $^3/_4$-in. rod takes 241 days to cure with the time required for drying. Rods larger than $^3/_4$-in. are, therefore, no longer made. A 1-in. rod takes a year for both the curing and drying.

Warped sheets are straightened by pressing between hot plates and cooling under pressure. Rods are usually straightened by immersing in hot water and then forcing them into grooved straightening boards where they cool under pressure. Very special straightening of rods is done under hot plates, etc., but regular commercial straightening is not. All rods are ground to the required diameter. Occasionally they are polished if the customer pays for it, but polishing is not the rule. Sheets are rarely sanded, but are sold with the surfaces as they come from the sheet molds. Any sanding that is done is usually to roughen the surface for gluing.

General characteristics

All casein composition is hygroscopic and is therefore affected by atmospheric moisture changes. Experience has shown that sheet stock in sizes larger than 4 sq. in., has a tendency to warp.

It can be readily understood that pieces molded to shapes of varying dimensions and thicknesses would cure more rapidly in the thinner sections during the immersion in formaldehyde and would not maintain the desired shape. This difficulty has deterred the use of casein plastic as a molding material and it is not available for such methods of plastic manufacture.

Casein plastic is made in a large range of opaque and translucent plain colors. Many mottled effects are also marketed. Originally these were principally imitation of horn, but now many different types are made, such as metallics, mosaics, pearl, jade, and other semi-precious stone effects. However, molding of casein is being done on items where close dimensions are not required.

It can be sawed, ground, cut, turned, and carved without difficulty and manufacturers equipped to work metal, wood, pearl, and similar materials find that much of their equipment can be used in the working of casein plastic. It is suitable for working on high-speed automatic or semi-automatic machines, and large quantities of articles are fabricated from casein rods on such equipment.

The fine and lasting polish which can be applied to casein plastic is one of the valuable features of the material. Formerly this was applied by smoothing the surface with powdered pumice stone and sawdust in tumbling drums or on rag buffing wheels and finishing with tripoli, wax, or rouge in tumbling barrels containing wooden pegs or by means of the rag buff. Now, the smoothed articles to be polished are placed in a hypochlorite bath heated to a maximum of 150 deg. F.; this treatment can also be carried out very satisfactorily with the solution at room temperature. After 2 to 5 minutes, the articles are removed from the bath, rinsed, and dried. The surface is soft when removed from the bath but sets to a glaze upon drying. This latter development is of particular importance to the firms manufacturing buttons from casein. Not only is the "dip polish" considerably less expensive than wax polishing in tumbling barrels, but the finish produced stands up under the conditions of cleaning and pressing used in most dry-cleaning establishments in the United States.

Developments during 1939

There have been numerous gradual improvements in casein plastic manufacture and fabrication since Christ-

ensen in 1929 patented the incorporation of about 2 percent of a water-soluble aluminum salt in the soft plastic to give a material rigid enough to be worked in automatic machines. Buttons varying in diameter from 1/4 inch to 2 1/2 inches are turned directly from rods of alum casein and are hardened in the formaldehyde bath in 3 to 5 days because the thin sections permit ready penetration of the aldehyde. This process enables casein plastic to compete with vegetable ivory and bone in the button trade which is its principal outlet today.

The production of synthetic fiber from casein has aroused considerable interest abroad. This problem was investigated by Dr. Antonio Ferretti from 1924 to 1935 and culminated in the manufacture of artificial wool by the Italian rayon company, Snia Viscosa, under the trade name "Lanital," meaning "Italian wool." Fabrics are usually made of blends of 50 percent Lanital and 50 percent wool and are said to be suitable for uniforms, underclothing, and miscellaneous men's wear. They are reported to be resistant to creasing and to attack by moths and to be as warm as wool, but are subject to decomposition by certain bacteria and reflect the weakness of Lanital when wet.

According to statistics presented in a book on *Casein and Its Industrial Applications* by Sutermeister and Browne, published during 1939, the annual consumption of casein plastics in the United States as sheets and rods is 56 tons and the amount of casein plastic converted into buttons and buckles by the seven firms engaged in this business is between 4000 and 5000 tons annually.

Mention should also be made of the research and development work which is underway to utilize proteins from other sources than milk as raw materials for plastics. Chief among these are soybean protein and zein obtainable from corn. The conversion of these materials into plastics suitable for injection molding and into transparent foil for wrapping purposes are major objectives in the experimental investigations now being conducted in several laboratories.

Forms available

Sheets—Standard size 16 by 20 in. by 2, 3, 4, and 6 mm. in thickness. Other thicknesses up to 12 mm. are made to order but sheets are not made thinner than 2 millimeters.

Rods—Available approximately 42 in. long and in diameters from 1/4 in. to 5/8 in., inclusive, in a large range of colors. Some colors are available in 3/4 in. diameter. Rods as small as 1/16 in. in diameter are produced by grinding 1/4 in. rods to the desired size.

Tubing—Made to order in small diameters. The diameter is ground to the desired size but the bore cannot be held to accurate dimensions.

Disks—Cut to practically any desired size from 3/8 in. to 2 1/2 in. in diameter. As a rule they are not cut thinner than 2 mm. or thicker than 6 mm. Miscellaneous shaped pieces punched from flat stock are also made to order for specialized fabrications.

Methods of fabrication

Chemical hardening: Button blanks, etc., formed from casein are immersed in formaldehyde solution to make the plastic hard and durable.

Machining: Articles are cut or ground to desired shapes from sheets, rods, and disks.

Typical applications

Buttons
Buckles
Beads
Game counters
Novelties
Trimming accessories

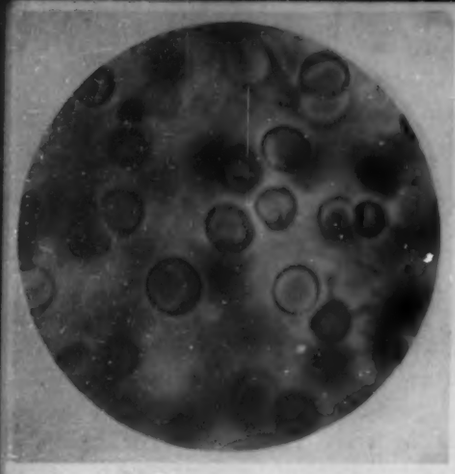
Outstanding properties

Colorability
Non-flammability
Ease of polishing
Ease of machining
Hygroscopicity

Trade name

Ameroid, Gala, Galorn

Some idea of the variety of useful items being fabricated from casein may be obtained by referring to this collection (at right) submitted by the American Plastics Corporation



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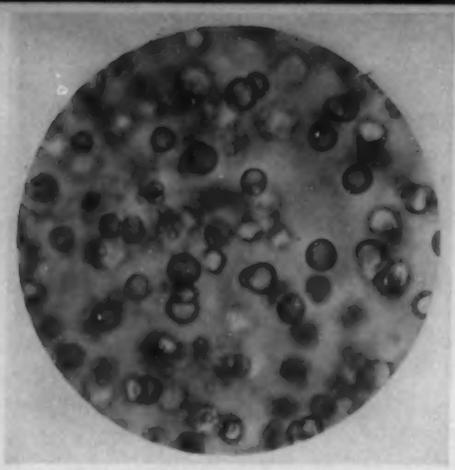

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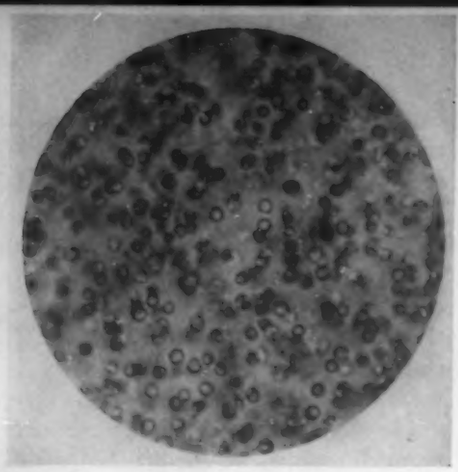

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CAST PHENOLIC RESINS

by W. R. THOMPSON*

IN THE EARLIER WELL-KNOWN PROCESSES FOR the manufacture of phenolic resins the chemical reaction between approximately equimolecular proportions of phenol and formaldehyde was carried out in the presence of a contact agent or catalyst. As the reaction progressed with the generation of heat, definite clouding or turbidity appeared indicating the formation of two liquid phases—phenolic resin and water layer. Such a system was commonly termed "hydrophobic" because the resin had little affinity for the water phase.

The process as used today for the manufacture of cast resin is fundamentally different. At no time during the operation prior to the gel formation is there a separation of resin from the solvent water. In short, certain new and novel steps in operating procedure are followed so as to give the desirable, non-separated resinous product. Because of its water holding properties such a system is said to be "hydrophilic."

Chemistry of cast phenolic resin manufacture

Among the salient features of the operation we might enumerate the following:

a. A relatively high formaldehyde mol ratio to phenol to insure the attachment of two or more formaldehyde molecules (—CH_2OH groups) on the phenol ring at the para and ortho positions with respect to the hydroxyl group.
b. The concentration of the alkali catalyst such as to cause the formation of a relatively high percentage of the potassium or sodium salts of the intermediate phenyl alcohols.
c. Neutralization and acidification of the intermediate product after condensation but before gelation to give an alkali salt of an organic acid having definite hydrophilic properties.

While condensation and polymerization may go on simultaneously, it is generally assumed that the steps of condensation include the initial reaction between phenol and formaldehyde with a catalyst, and subsequent acidification and dehydration under vacuum to give a light colored, fusible, and soluble resinous product of honey-like consistency. In this condition it is poured hot into open lead molds, split molds, glass molds, etc., preparatory to hardening by heat.

As gel formation or polymerization takes place at approximately 80 deg. C. under atmospheric pressure, separation of the residual water occurs as a highly dispersed colloidal phase which causes complete scattering of light and produces opacity in the product.

Quantitative measurements show the optimum particle size of the dispersed colloidal water phase necessary to obtain definite characteristics and properties in the final infusible, insoluble product.

The representative photomicrographs used as illustration were made at 2000 diameters from a typical hydrophilic resin having water contents varying from 14.15 percent to 8.60 percent. A measurement of these water particles showed a variation in size from 0.2μ, the limit of resolution, to 10μ.

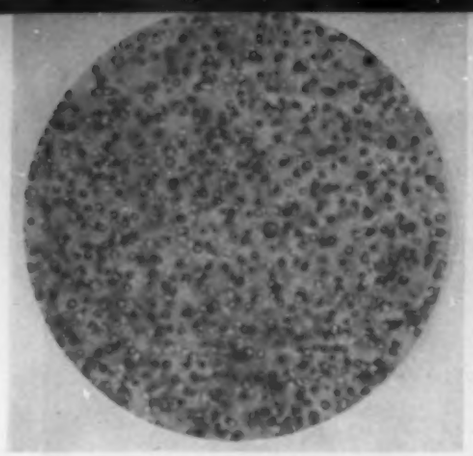
Fig. No.	1	2	3
Water content	14.15%	12.64%	10.52%
Particle size	6–8μ	3–4μ	1.5–2μ

Fig. No.	4	5	6	7
Water content	10.33%	9.46%	9.00%	8.60%
Particle size	1.00μ	0.5μ	0.2μ	——

This study exhibits a most striking contrast and shows wide and controllable variations in opacity and translucency of cast phenolic resins.

When glycerine or its chemical equivalent is added even in small quantities to cast resin it has a marked effect, especially upon the physical properties. Its function is that of a common solvent which has an affinity both for the water and resin base. Consequently, when the resin is fully polymerized, translucency or even transparency results because the size of the water droplets approaches or is shorter than the wave length of visible light.

* Chief Chemical Engineer, Catalin Corp.



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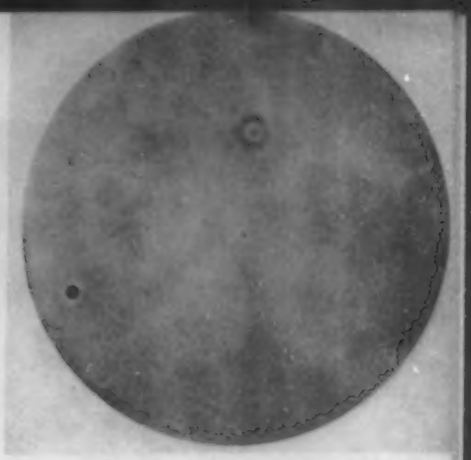

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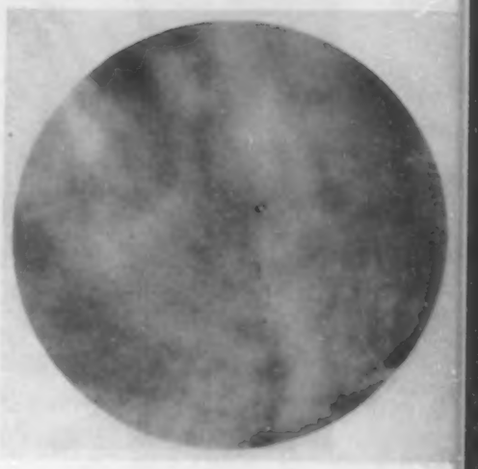

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Figs. 1–7 illustrate the progressive decrease in the water droplet size resulting from dehydration of typical hydrophilic resin. (Magnification—2000 diameters)

General characteristics

By virtue of their remarkable physical properties cast resins are able to meet the many demands required of a modern plastic. Unusual ranges in transparency, translucency, and opacity are permissible merely by controlling the size of the water droplets without the use of pigments. Further addition of dyestuffs and pigments permits a wide variety of shades and hues both in plain colors and in attractive mottled effects.

Because of their brilliancy and glassy transparency it might be assumed that cast resins possess inferior strength. In spite of the total absence of fibrous fillers, materials commonly used in the molded types, the compressive, tensile, and flexural strengths of the cast products are unusually high and wholly adequate for prac-

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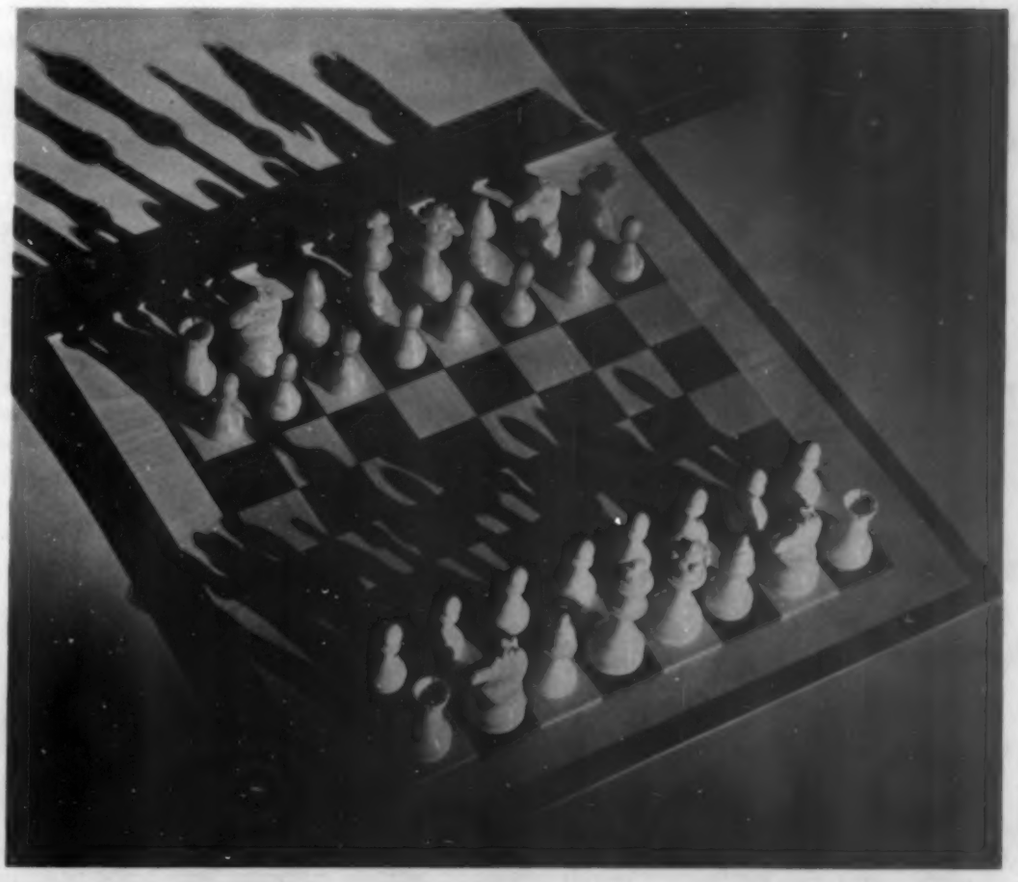

Cast phenolic rods are turned into beautifully carved chessmen by expert craftsmen. Plain colors predominate but mottles are occasionally used. Pieces shown in Fig. 8 are Catalin

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Lamp bases, tableware handles, chafing dish handles, book ends, poker chips, mah jong playing pieces and racks, clock cases, compacts, desk sets, cigaret cases and display pieces, all use this colorful material. Those in Fig. 10 are Marblette. The Theon display (Fig. 9) is Bakelite cast resinoid

tically any application. Furthermore these products are non-inflammable and non-absorbent. They possess little or no odor, are tasteless and hygienic.

With such merits it was only natural to meet the demands of the laminator for a light colored phenol resin in liquid form for laminating thin sheets of paper together into attractive light-colored translucent panels for industrial and decorative uses such as Venetian blinds, advertising signs and displays, lamp shades, graphic charts for permanent records, radio tuning dials, etc. This modern, odorless, laminating varnish produces a product which is strong, durable, waterproof, and heat-resistant. It is receptive to embossing, printing, and stamping operations. Perhaps its outstanding merit is almost unlimited color possibilities.

Cast phenolic resins have excellent adhesive properties. Laboratory and field tests have proved conclusively that the use of these alcohol-soluble products simplifies the application, control, and utility of resin glues for hot-pressed plywood. The products obtained are waterproof and vermin-proof and have shear strengths which are from 15 to 20 percent higher than those formerly obtained with dry film glues.

Developments during 1939

Unquestionably the biggest and most promising expansion during the past year was the adoption of cast resins for industrial uses, principally translucent panels, pilasters, and domes for cigaret cabinets and music box assemblies. Colors were chosen for their ability to give striking effects both by reflected and transmitted light, the latter being supplied by lighting units within the cabinet. Pilaster castings which went into the assembly measured up to 40 in. in length with a diameter from 6 to 12 in. The weight of the separate castings varied from 3 to 10 lbs. Such an application would have been impossible with glass fittings because of the tremendous die cost. By the use of new and improved casting methods this excessive cost was eliminated. Moreover, the lightness in weight as compared to glass, rigidity and tensile strength, translucency and stability of color are only a few of the reasons why cast resins were chosen.

To meet the need of a heat-resistant, non-absorbent, non-reactive cast resin, a new industrial product was announced during the past year. Already it has been accepted by a number of manufacturers who use this product for impeller and rotor parts of pumps, and its use is to be extended for piping in chemical, sanitary, and aqua installations.

Research to perfect a product to meet the exacting requirements of the brush trade was in part responsible for the general acceptance of cast resins in this field during 1939. For one particular premium brush item a special molding procedure was found helpful whereby a raised decoration or decalcomania was applied to the back of the brush to enhance its attractiveness.

Radio cabinets were produced in large quantities in numerous shapes and colors. Grilles were cast by new

production methods to permit unusual and complicated designs for ready assembly in a variety of contrasting colors. The combination of colors gave a pleasing effect when viewed under transmitted light.

Forms available

Cast polished sheets 12 in. by 24 in. in various thicknesses
Unpolished sheets cut from blocks 32 in. by 72 in. in various thicknesses
Cast rods, sheets, tubes, and blocks
Special profile castings
Two-tone castings
Split mold shapes
Resin solutions in organic solvents
Liquid cements
Clear and opaque casting resins for hot or cold setting

Methods of fabrication

Users are supplied with castings in a fully hardened and easily workable form according to accurate blue prints submitted by the customer. Thereupon the castings are fashioned to give the final finished product by one or more standard machining operations including sawing or cutting, drilling, threading, forming, carving, embossing, turning, milling, ashing, polishing, etc.

Casting: Heat setting liquid resins are poured into suitable molds of glass, rubber, or lead, and heated for 48 hours at 78 deg. C.

Typical applications

Industrial cabinet housings
Novelties and decorative articles
Advertising signs and displays
Radio boxes
Kitchen utensils and cutlery handles
Brush backs
Fixtures for interior lighting
Adhesives
Laminating varnishes

Outstanding properties

Colorability from transparency to opacity
Machinability
Non-inflammability
High tensile and impact strength
Rigidity

Trade names

Bakelite Resinoid, Catalin, Gemstone, Marblette, Monsanto Cast Phenolic, Prystal.

The unusually large disks (Fig. 11) are Monsanto cast phenolic. They are 33 in. in diameter and 1 1/8 in. thick Firestone used them at the New York World's Fair. Fine costume jewelry is fabricated from cast resins which may be machined into intricate forms and polished to a high luster. Those shown in Fig. 12 are Gemstone

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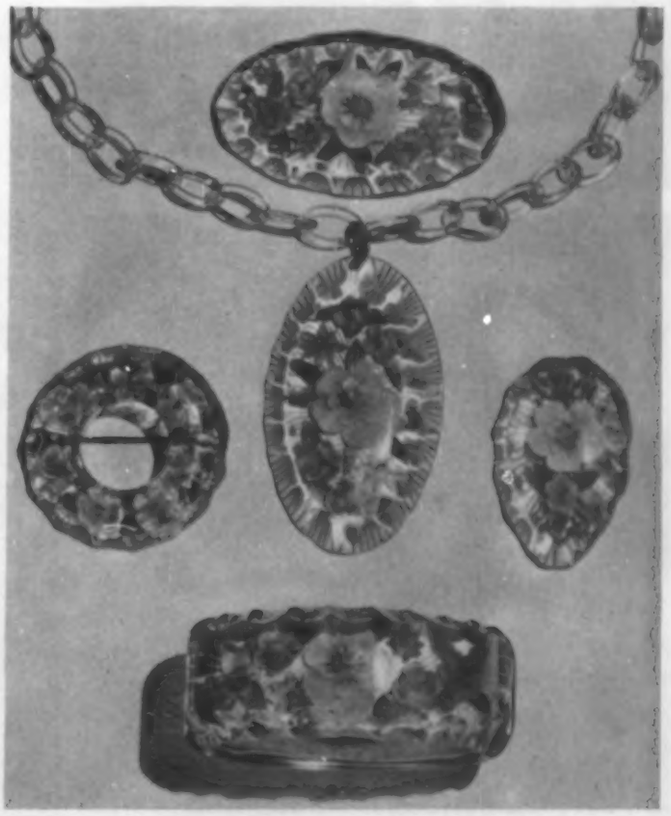

CELLULOSE ACETATE

by H. K. HAVILAND*

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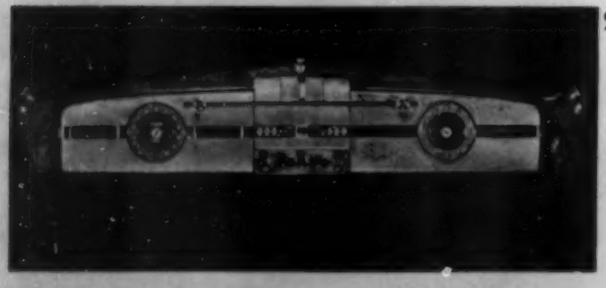

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CELLULCSE ACETATE PLASTICS BELONG TO THE family of cellulose derivative plastics which include the inorganic and organic acid esters of cellulose, such as cellulose nitrate and cellulose acetate, respectively, and the cellulose ethers, of which ethylcellulose is the outstanding example. Cellulose is the base common to all types. It is produced in a highly purified state from cotton linters.

Cellulose acetate has been known since the early experimental work of Schulzenberger and Naudin from 1856 to 1869. These early cellulose acetates were mostly of the completely acetylated type, soluble in chloroform and other chlorinated hydrocarbons which are regarded as highly toxic. Miles in 1905 discovered that acetone-soluble products could be obtained by a partial saponification of the highly acetylated esters. It was not, however, until the outbreak of the World War that any substantial commercial progress was made. War demands for airplane wing coating materials accelerated the development and production of cellulose acetate and also suitable solvents and plasticizers for that purpose. Plants left idle at the close of hostilities were soon occupied in the manufacture of cellulose acetate silk. Adequate and economical production of cellulose acetate thus assured, investigators turned to plastics, the first of which appeared commercially in this country about 1926.

Chemistry of their formation

Both chemical and physical processes are involved in the manufacture of cellulose acetate plastics. They are

* Celluloid Corp.

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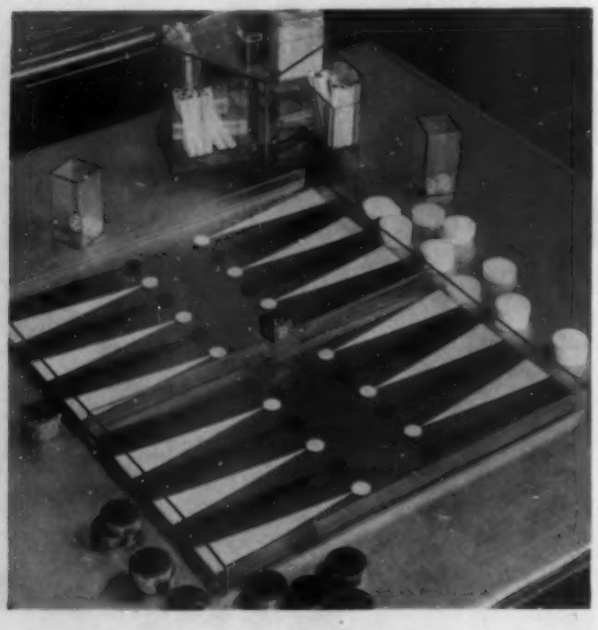

not pure chemical compounds, but rather solid or colloidal solutions of cellulose acetate in plasticizers.

Cellulose acetate itself is made by treating cotton linters with acetic acid and acetic anhydride in the presence of a catalyst such as sulphuric acid. Cellulose triacetate of about 63 percent acetic acid content is formed by the reaction. It is soluble in the treating acids forming a heavy dope. The dope is cured with the addition of water to partially hydrolyze or deacetylate the cellulose triacetate. The cellulose acetate is then precipitated in water, washed and dried, in which form it is soluble in acetone and is suitable for the manufacture of plastic materials.

For the conversion or colloidalization of cellulose acetate, plasticizers are required. These are generally oily liquids of high boiling point and low vapor pressure which have a solvent or geling action on the cellulose acetate. Several types are used, either singly or in combination, the amount and type depending upon the characteristics desired in the finished plastic. Among the plasticizers commonly used are: dimethyl phthalate, dibutyl tartrate, triacetin, para-toluene ethylsulphonamide. To this number may be added triphenyl phosphate, which also has excellent fire-retarding properties.

The cellulose acetate is mixed in a kneader with suitable quantity of plasticizers and volatile solvent such as acetone and alcohol until a jell-like colloidal mass is obtained. The colloid is then worked on heated malaxating rolls with the addition of dyes or color pigments until the colors are thoroughly incorporated and dispersed throughout the mass. Subsequent steps in the process depend upon the form of plastic desired. For molding powders, volatile solvents are removed and the material is ground in a mill to the desired size of granules. If cut sheets are preferred, slabs are taken from the rolls, stacked and pressed with the aid of heat into solid blocks about 2 ft. by $4\frac{1}{2}$ ft. by 6 in. in dimensions. The blocks are then sliced on a planer into sheets ranging in thickness from 0.005 in. to over 1.0 in. The sheets are seasoned to remove volatile residual solvents and polished by pressing under heat between polished nickel-plated steel plates. Films and foils are made by casting a dope on a moving polished surface. The volatile solvents are evaporated and the resulting film is stripped from the support, dried and wound into rolls. Films from 0.0005 to 0.010 in. thick can be made by this process.

General characteristics

Cellulose acetate plastics are truly thermoplastic. They are softened by the application of heat and harden again upon cooling. This cycle of softening and hardening may be repeated without any chemical change taking place in the material. The degree of plasticity may be controlled over a wide range by varying the amount and type of plasticizer as well as the characteristics of the basic cellulose acetate itself. The plasticity or flow is thus easily adjusted to that degree which is best suited to the particular method of molding employed and to the particular form, size or shape of the article to be made. In other words the material is custom built for the application.

Mechanical strength and toughness are outstanding characteristics of acetate plastics. Rugged and durable articles can be molded or formed with relatively thin cross sections. Prominent examples are the injection molded oil cans and the great variety of fabricated transparent containers. To mechanical strength is added wear-resistance. Molded steering wheels, window raiser knobs and other automotive hardware retain their initial high polish through long use where other materials fail.

The fine electrical properties of cellulose acetate materials are being widely utilized in the electrical industry. Even after soaking in water the electrical resistance is surprisingly high. Thin foil wrapped

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Versatile and capable of injection or compression molding, cellulose acetate is molded into door knobs and handles (Fig. 1) by Thermo-Plastics, Inc. Sheller Mfg. Co. molded the pearl-like instrument panel (Fig. 2) for Packard Motor Co. Stewart-Warner's remote control (Fig. 3) was molded by Gits Molding Corp. All were molded of Tenite. Sheet acetate is versatile, too. The backgammon board and shaker as well as the four-compartment cigaret box (Fig. 4) are fabricated of Plastacele by Cora Scovil. Colorful knobs and drawer pulls (Fig. 5) are molded of Bakelite cellulose acetate by Hahn Plastic & Die Cast Corp., and called California Ware

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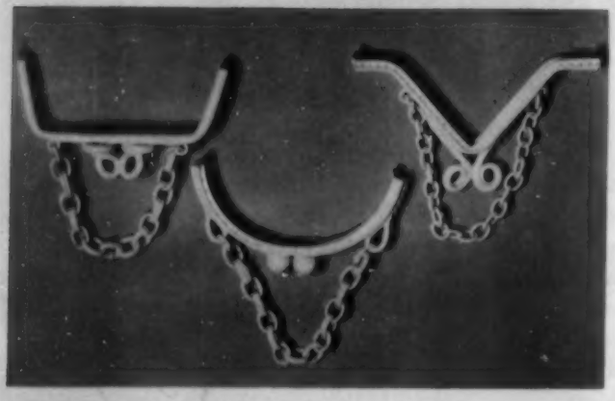

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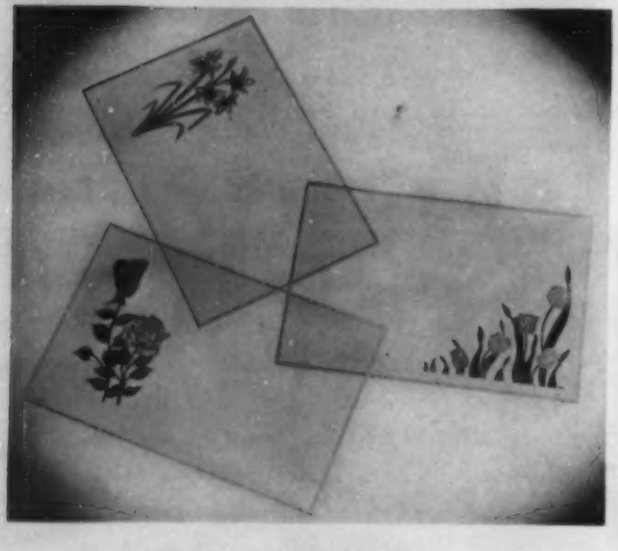

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Gavels (Fig. 6) were fabricated of Monsanto cellulose acetate by the Shoreham Manufacturing Co. Bag frames (Fig. 7) were fashioned of the same material by Rex Products and Gold Seal Button Works, Inc. Table mats (Fig. 8) are of transparent Lumarith, printed in gay colors by Ellison & Spring, Incorporated

directly over copper wire offers an ideal insulation for many applications where economical use of space is important. Injection molded parts are also used in many types of electrical equipment.

Unlimited color possibilities are the invaluable tools of the artist and designer. Cellulose acetate plastics may be obtained in transparent, translucent and opaque color in all shades of the spectrum or in crystal clear form. By mixing of colors all sorts of configurations are possible, many in imitation of products of nature such as mother-of-pearl, tortoise shell and onyx, and others in original fanciful variegations of many hues.

Developments during 1939

During the past year cellulose acetate has made progress in product improvement and has broadened its scope of usefulness. Formulations for injection and compression molding have been improved and classified according to type and degree of flow. Powder formulations have advanced with injection molding machine developments. Multi-cylinder machines now inject up to about two pounds of material per stroke in such articles as steering wheels, radio housings, window reveals, toilet seats and other large articles.

Clarity and transparency, dimensional stability and moisture absorption have all been improved through more selective formulating and advanced processing technique. These qualities have contributed to improved material for airplane window and formed cockpit cover, and also to the preference being shown for cellulose acetate watch crystals.

Wider acceptance of cellulose acetate is evidenced in the automobile industry. Practically all 1939 models in all price classes have at least some interior appointments molded of cellulose acetate. The number of molded parts has increased from control knobs, escutcheon and horn buttons to steering wheels, radio grilles, instrument panels and in some current models to a unique development in the molded glove compartment door.

New applications in the electrical field include laminated slot insulation paper and direct winding of bare and enameled wire with thin acetate foil. The high breakdown voltage and insulation resistance of cellulose acetate permits the use of very thin foils. For slot insulation the foil is laminated to insulation paper for mechanical strength. The laminated papers are thinner than ordinary insulation paper of equal dielectric strength and, therefore, afford an appreciable saving in space. Cellulose acetate wire insulation is inert to transformer oils, is not corrosive to copper wire and has marked resistance to humidity.

Transparent containers of the rigid type made from sheet stock have advanced with tremendous strides in 1939. Large cannisters for kitchen use have been especially featured.

A novel application recently marketed is a storm enclosure consisting of waterproof paper with a cellulose acetate window which can be attached to door screens without removing the wire screen. Hotbed frames,

storm sash and solarium enclosures are being made with acetate film in place of glass because of its light weight, heat insulating qualities and its property of transmitting most of the beneficial ultraviolet rays of the sunlight.

Among other new applications may be mentioned molded duck pins for bowling which outlast wood, injection molded shoe-heels which cannot scuff, and bathroom fixtures to match any color scheme.

Forms available

Injection molding powder.
Compression molding powder.
Cut sheets in standard sizes 20 in. by 50 in. by any thickness from 0.005 in. to over 1 in.
Films and foils in continuous lengths up to 42 in. wide, in thicknesses from 0.0005 in. to 0.020 in.
Cylindrical and profile extruded rods.
Extruded tubing.

Methods of fabrication

Compression molding at 290–350 deg. F. and 2000 to 5000 lbs. per sq. in. pressure. The material is cooled under pressure to harden. No heat curing is required.

Injection molding in all standard machines.

Mechanical operations such as milling, turning, punching, sawing, drilling, etc. The material machines very similar to soft metals, the same type of tools can be used. Automatic screw machines may also be employed. Parts may be cemented together or joined mechanically by rivets, screws, etc. A high lustrous polish is obtained by buffing wheel or tumbler polishing. Dip polishing or lacquering is also for many articles.

Dry swaging or drawing: Many containers, covers, watch crystals, etc., are drawn from sheet stock by hot swaging operations.

Typical applications

Automobile steering wheels and hardware.
Lamp shades and lighting accessories.
Watch crystals.
Airplane cockpit enclosures.
Decorative novelties.
Transparent containers.
Fountain pens and mechanical pencils.
Electrical appliances.
Combs and toilet articles.
Spectacle frames and protective goggles.
Instrument and radio panels, dials and control boards.
Costume jewelry.

Outstanding properties

Mechanical strength
Transparency
Colorability
Fabricating versatility.
High dielectric strength.
Moldability.

Trade names

Bakelite Cellulose Acetate, Lumarith, Masuron, Monsanto Cellulose Acetate, Nixonite, Plastacele, Tenite.

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Lumarith is used for the hand-carved jewelry (Fig. 9) made by Paristyle Button Co. The cowboy pistol (Fig. 10) is made attractive to youth by its smooth Bakelite acetate handle molded for Kenton Hardware Co. by Plastics, Inc. Fig. 11—Drypoint etching is simplified by tracing a picture through acetate sheet. Plastacele is the material used and etching kits are available through the du Pont Company

Typical examples of molded cellulose acetate butyrate include (left to right) the Tot Speed Fastener, molded by American Insulator Corp.; Usalite, in which the flashlight body, lens and switch are molded by General Electric Co.; and the Nasalators, molded by Merrigan Plastics for Frederick Stearns & Co. The material is designated as Tenite II

CELLULOSE ACETATE BUTYRATE

by C. H. PENNING*

AFTER CAREFUL INVESTIGATION OF VARIOUS mixed esters of cellulose for a number of years, a molding composition has been perfected and produced from one of these mixed esters, i.e., cellulose acetate butyrate. It is especially adapted for injection molding, but is also suitable for compression molding. In December 1938, this cellulose acetate butyrate molding composition was offered to the trade. Its superior properties brought immediate acceptance.

Chemistry of formation

Chemically, cellulose acetate butyrate is a mixed ester of cellulose made by combining, simultaneously, butyryl groups from butyric acid and acetyl groups from acetic acid, the combination taking place at the hydroxyl groups of the cellulose. The ratio of combined butyric acid to acetic acid depends upon the process employed in producing the ester. Cellulose acetate butyrate lends itself to hydrolysis, during which process part of both the acetyl and butyryl groups are replaced with hydroxyl groups. By these means the solubility and compatibility properties may be varied.

General characteristics

Cellulose acetate butyrate is a white flaky or granular material, similar to cellulose acetate in appearance. It is lighter in weight than cellulose acetate, having a specific gravity of 1.21 compared with 1.31 for the acetic acid ester. This same specific gravity ratio is also found in molding compositions made from the two materials, with the result that volume for volume an object molded from cellulose acetate butyrate material weighs approximately 6 percent less than one molded from a cellulose acetate.

Cellulose acetate butyrate compositions have excellent weathering resistance, due in part to the relatively low moisture absorption of cellulose acetate butyrate. On continuous immersion, cellulose acetate butyrate plastic absorbs about one-half as much water as cellulose acetate plastic and, in fact, approximates the water absorption of nitrocellulose plastic. In addition, cellulose acetate butyrate molding composition is made with a relatively low percentage of plasticizer content and the plasticizers used have greater water resistance and lower vapor pressure than those used in cellulose acetate plastics. Consequently there is improved resistance to distortion under varying conditions of temperature and humidity.

In molding cellulose acetate butyrate material, flow increases uniformly with temperature up to a certain point; beyond that critical temperature the material flows considerably faster. This temperature varies according to flow designation. For example, the critical temperature for injection type H4 Flow is approximately 331.5 deg. F., and for S2 Flow approximately 272 deg. F; and for compression type H4 Flow is approximately 328 deg. F., and for S2 Flow, approximately 276 deg. F. As a consequence of this characteristic, the cellulose acetate butyrate composition requires less pressure for molding than does a cellulose acetate material of the same flow designation. Correspondingly, it is possible to mold harder flows of acetate butyrate, with resultant production of molded articles having increased resistance to heat. Articles injection molded from acetate butyrate composition of H2 flow have been kept in boiling water for five minutes without the impairment of surface luster.

Because of the lower viscosity of the heated plastic after it reaches the critical temperature, injection molded articles of cellulose acetate butyrate have improved

* Tennessee Eastman Corp.

strength at the weld and show fewer flow lines in thick sections. This results in an improved finish.

Despite the better flow of an acetate butyrate plastic at higher temperature, it may be desirable to use warmed molds for the injection of material of the harder flow designations. A hard material injected into a warm mold has much greater strength than the same material injected into a cold mold because there is a more complete welding of the material and an absence of apparent flow lines. Only a certain temperature differential is required between the hot material and the mold in order to permit satisfactory "setting" and ejection of the mold piece. Accordingly, within limits, the higher the temperature required in the injection cylinder the higher can be the temperature of the mold. When the temperature of the mold is below the optimum range there is of course difficulty in filling the mold or flow marks appear because the material sets up too rapidly. When the mold temperature is above the limit of the satisfactory working range, castings stick in the cavities, are marred by the knockout pins or become distorted on ejection. There is, however, a good working range within which the same cycle can be maintained as when working with the usual softer flows injected into cold molds.

Because of the relative ease of injecting harder flows of acetate butyrate plastic there has been a tendency for molders to use harder flows than are necessary for certain jobs. It remains true that harder or stiffer compositions have less resistance to impact; thus they should be used only when resistance to heat in the molded object is of paramount importance.

Forms available

Cellulose acetate butyrate flake and granulation, suitable for making solutions, are available in a number of types which vary in three ways: (1) total acyl content, (2) relative proportion of acetyl to butyryl and (3) viscosity. Cellulose acetate butyrate molding composition is available in granular form for both injection and compression molding and in sheet or blank form for compression molding only.

Typical applications

Cellulose acetate butyrate, in flake or granular form, can be used in the same manner as cellulose acetate for the manufacture of transparent sheeting, lacquers and coating solutions of all descriptions, including airplane dopes. Fortunately, it is soluble in a wider range of solvents and compatible with quite a few more gums, resins and plasticizers than is cellulose acetate. By incorporating gums and resins into a lacquer made from cellulose acetate butyrate, its adhesion to metal, glass and paper is materially improved, thus eliminating one of the difficulties with cellulose acetate as a protective coating material. In addition, certain types of cellulose acetate butyrate have considerably greater moisture and weathering resistance than does cellulose acetate.

Cellulose acetate butyrate molding composition, because of its permanence properties, is particularly suited for applications which require resistance to distortion under varying degrees of heat and humidity—especially such conditions as exist on exposure to the weather. Automobile tail light lenses, for example, are being molded from this material in increasing numbers. Automobile emblems, direction indicators and fender guides are other obvious applications. Another large field is presented by interior refrigerator parts such as compartment doors and handles, thermometer casings, etc. Combs and tooth brush handles—articles requiring frequent cleansing—are advantageously made from this material. For the fisherman there are fishing reel ends and handles, ferrules for rods, artificial bait and fly boxes.

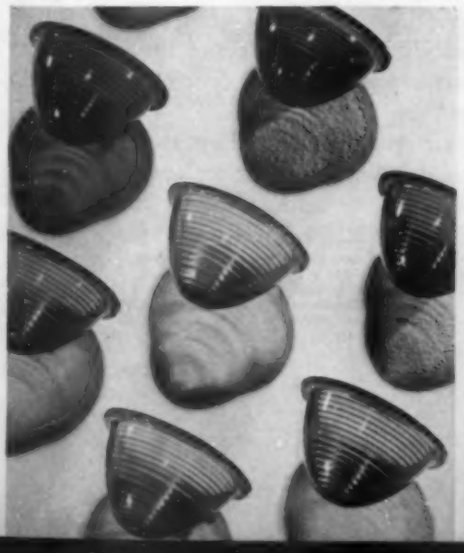
Outstanding properties

Weathering resistance
Low water absorption
Unique flow characteristics
Compatibility with resins and plasticizers

Trade name

Tenite II

Courtesy lamp lenses, molded by Metal Specialties Co. for K-D Lamp Co.; General Electric refrigerator thermometer casing and the AAA auto emblem and bracket, molded by Chicago Molded Products Corp.; all are injection molded of Tenite II



CELLULOSE NITRATE

by J. M. DeBELL*

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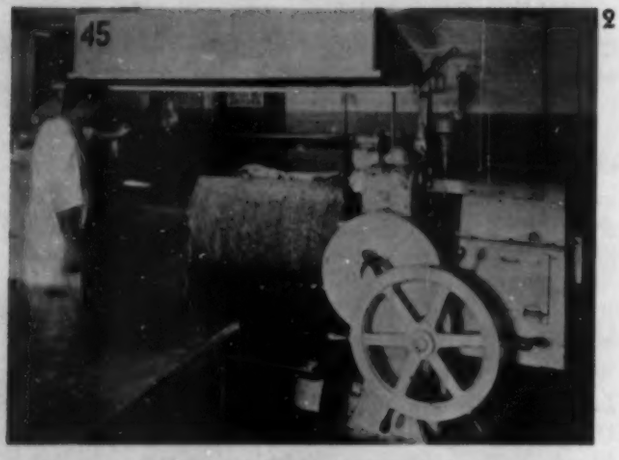

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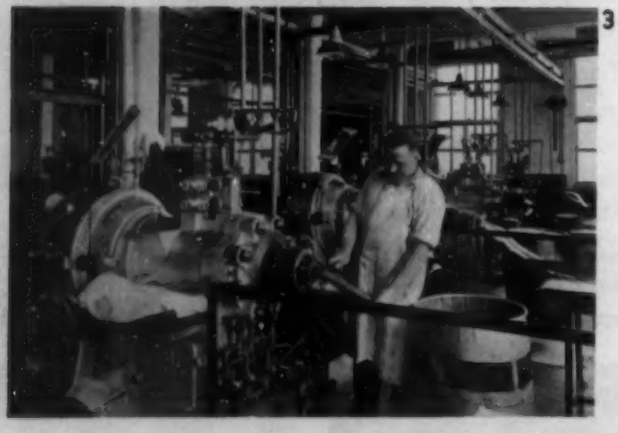

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In mixers like these (Fig. 1), cellulose nitrate is thoroughly blended before going through additional steps of rolling (Fig. 2), caking, sheeting and curing. Fig. 3 shows how the material is extruded into rods. (Photos 1, 3, 4, and 6 were taken in the plastics department of Monsanto Chemical Co. Photos 2 and 5 are of the Celluloid Corp. plant)

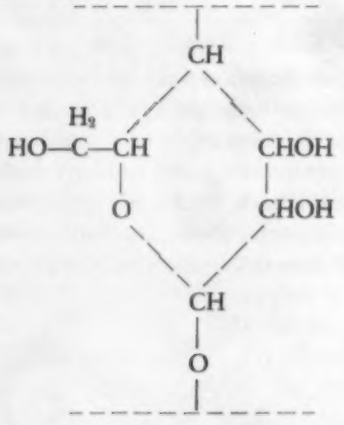
CELLULOSE NITRATE, THE MOST VENERABLE member of the chemical plastics field, continues to maintain good volume in its three established uses of explosives, protective coatings, and plastics; although in the last of these three it now finds itself yielding place in poundage to its more vigorous relative, cellulose acetate, on account of the spectacular development of the molding powders made from the latter material.

The history of nitrocellulose and the plastics produced from it have been frequently summarized,[1] the successful industrial use extending from the preparation of the base material by Schönbein,[2] with the plastic work initiated by Parkes and the Hyatts.[3] Since those remote times the improvements, although major, have been mainly in the field of controlling manufacture, controlling viscosity, and improving stability, together with a host of practical uses.

Chemistry of the product

Since the work of Meyer & Mark,[4] the following basic structure has been generally accepted for cellulose itself:

GLUCOSIDIC UNIT OF CELLULOSE



Units of this type are strung together in lengths up to 3,000 to 3,500.[5] Cellulose may, therefore, be considered as a polyhydric alcohol, amenable to the usual reactions of the aliphatic alcohol groups, but limited by the complexity of the molecule and the mechanical difficulties of attacking the fibers (cotton and wood) which are its source.

Cellulose nitrate is usually defined by its nitrogen content and its viscosity. For complete esterification, a

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* Plastics Dept., Monsanto Chemical Co.

(1) Worden, Nitrocellulose Industry (1911); Technology of Cellulose Esters (1921); Technology of Cellulose Ethers (1933)—D. Van Nostrand. Conaway, Ind. & Eng. Chemistry, v. 30, 516 (1938).
(2) Schönbein, J. Prakt. Chem., 34, 492 (1845); British patent 11,407 (1846).
(3) Worden, Technology of Cellulose Esters, Vol. 1, Page 2655.
(4) Meyer and Mark, Ber. 61,593 (1928).
(5) Kraemer, Ind. & Eng. Chemistry, v. 30, 1200 (1938); Kraemer and Lansing, J. Phys. Chem., 39,153 (1935).

nitrogen content of 14.16 percent would be required in the finished product. Actually, nitrogen in cellulose nitrate used for plastics usually ranges from 10.5 to 11.5, with lacquer nitrocotton being nearer to 12 percent nitrogen, and explosives nitrocotton nearer 13 percent.

Viscosity depends on the amount that the cellulose chain has been broken down into shorter units. The greatest degradation occurs in the case of lacquer nitrocellulose, where the viscosity is reduced to 1/4 to 6 seconds as determined in a 12.2 percent solution by the Hercules falling ball method.[6] For plastics work, the viscosity is considerably higher.

In manufacture, carefully purified cotton or wood cellulose having a high alpha cellulose content is conditioned to the desired water content and is then treated with a mixture of nitric and sulphuric acid. Controlling factors are the shape and density of the cellulose chips, the relative amounts of nitric acid, sulphuric acid and water, and the time, temperature and agitation of the nitration operation. Spent acid is subsequently drained off, the nitrated material is given prolonged treatments with hot water, bleached, boiled again in water, and is finally subjected to the dehydrating operation by which, under hydraulic pressure, the water is largely replaced by alcohol. Viscosity control is usually effected by the nitrating treatment, or by subsequent digestion under heat and pressure; but as an alternative, the cellulose raw material may be degraded before nitration.[7] Fractionation of commercial nitrocellulose into various viscosities has been studied by Spurlin[8] and others. The alcohol-wet nitrocellulose is now ready for incorporation into plastic.

Camphor is still the standard plasticizer for cellulose nitrate, although small admixtures of other materials are occasionally used. The plastic is colloided in masticating mixtures with the plasticizer and solvents, and strained under hydraulic pressure while in soft condition. It is colored and simultaneously freed from solvent by sheeting on rolls, is baked under hydraulic pressure into cakes slightly larger than the standard 20 in. by 50 in. size accepted by the trade, is sheeted and seasoned over a considerable period to remove remaining solvents, and is finally press polished under low heat in hydraulic presses. Alternately, it may be extruded continuously as tubes, rods, or sheets.

These laborious operations have been required on account of the susceptibility of the plastic to high temperatures; but by the same token they have permitted a vast range of controlled and decorative effects which would scarcely be feasible by any other means of preparation.

General characteristics

Cellulose nitrate plastics have found favor because of their great toughness, water resistance, and brilliant clarity, which permit infinite color effects. During the last few years refinements of treating to remove last

(6) Gardner, Physical and Chem. Exam. of Paints, Varnishes, & Lacquers, 8th Edition, 571. See also A.S.T.M. Specifications D301-33T.
(7) U.S. 1,997,766, Cochran, Hitt & Van Taylor; 2,089,547, Schur; 2,080,934, Schur; 2,103,647, Schur; Richter, 2,112,116; 2,108,125, Hoddeson & Meiklejohn.
(8) Spurlin, Ind. & Eng. Chemistry, 30, 538 (1938).

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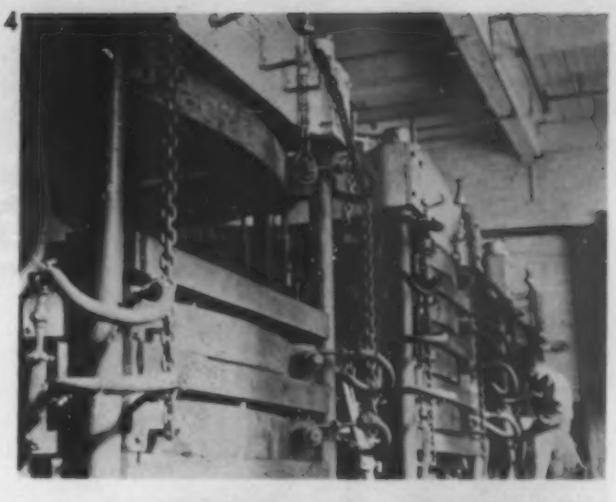

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Huge hydraulic presses (Fig. 4) are used to press polish acetate and nitrate plastic sheets and to form them into cakes which are sliced (Fig. 5) into thin sheets by a sharp blade. Inspection (Fig. 6) of sheet plastic materials is more rigid than the inspection of fine textiles. Trained operators catch every minute flaw

traces of sulphate have resulted in a surprising stability. Flammability has been the main drawback, although this has been considerably reduced by special plasticizers containing chlorine and phosphate as fire retardants. The plastic continues to be the favorite base for fountain pens because of its resistance to the chemicals involved; toothbrush handles on account of its toughness and beauty; drawing instruments, unbreakable watch-crystals on account of its clarity and water resistance; and a wide range of other similar uses from wood heel coverings and piano keys to dominoes.

In the protective coating field, cellulose nitrate continues to be the major constituent for conferring toughness, long protection, and quick drying at room temperatures or slightly above. It finds extensive use in artificial leather, adhesives and emulsions for coating of paper.

Developments during 1939

Since cellulose nitrate and its plastics have been so thoroughly investigated and exploited over a period of years, it is not unusual that there have been no startling developments during the past year. Nevertheless, improvements in control of color,[9,10] further use of wood cellulose as raw material, and extension of use for rapid drying printing inks,[11] have been made.

In the plastics field proper, there is an increased tendency toward the use of thin clear surface layers of colored plastic to give depth effects; and for window decoration from sheets containing dyes which give different colorations when they are viewed by reflected and transmitted light, respectively.

(9) Bouchonnet, Trombe and Petitpas, Bull. Soc. Chim. (5), 4, 1085–92 (1937).
(10) Delorme, Rev. Gen. Mat. Plast. 14, 46–9 (1938).
(11) Fernandez, R. O., Private Communication.

Forms available

Lacquers
Emulsions
Plastic rods
Plastic tubes
Plastic sheets in various thicknesses (20 in. by 50 in. standard)
Color chips
All in great variety of colors and patterns.

Methods of fabrication

Cutting
Sawing
Punching
Drilling
Drawing
Turning
Printing
Embossing
Polishing
Molding, by heating at 160 deg. F–220 deg. F. and pressing (mechanical or hydraulic)
Blowing, by placing softened sheets of the material in mold and forcing air between them.

Typical applications of plastic

Bag frames
Belting interliner
Blotters
Brushes
Buckles
Calendars
Clock dials & crystals
Cutlery handles
Dental plates
Dominoes
Drafting instruments
Eyeshades
Fountain pens
Golf club parts
Index forms
Labels
Mirrors
Novelties
Piano keys
Pencils
Razor handles
Rulers
Shoe eyelets & lace tips
Toilet seats
Tool handles
Toothbrush handles
Toys
Wood heel covers
Spectacle frames

Outstanding properties

Toughness
Water resistance
Ease of fabrication
Ease of cementing
Clarity
Colorability
Flammability

Trade names

Amerith, Celluloid, Monsanto Cellulose Nitrate, Nixonoid, Pyralin

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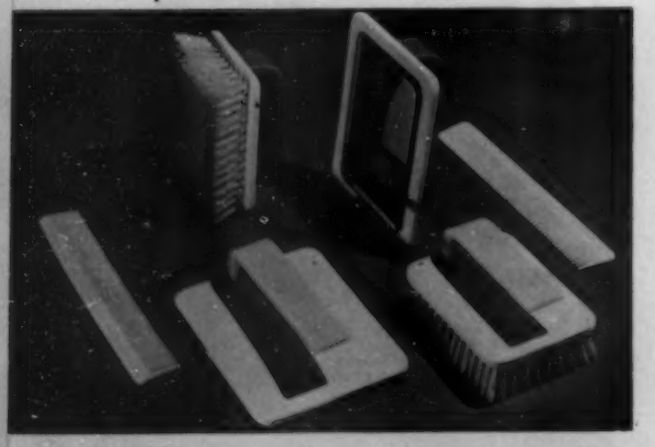

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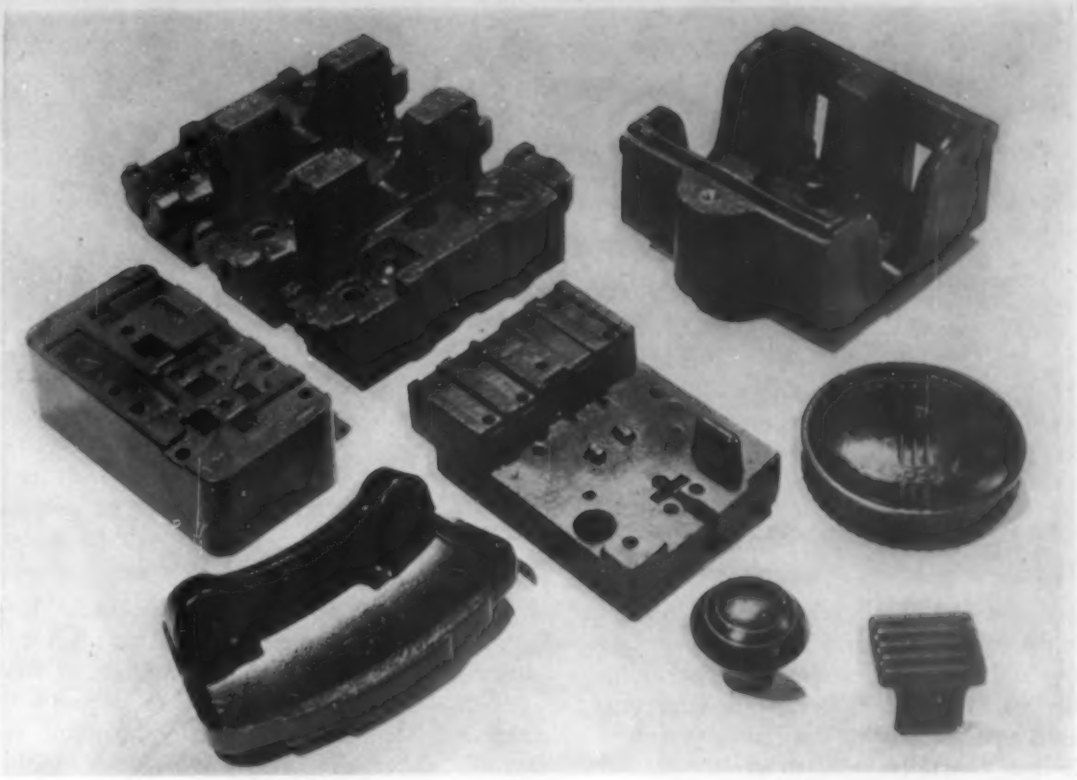
We can picture but a few typical applications, such as the utility set of Amerith (Fig. 7), the transparent Prophy-lac-tic brush back (Fig. 8) and the make-up table with revolving front whose top is protected and made attractive by the use of Pyralin



Cold molded parts are used generally in applications where electrical properties or heat resistance is desired. These are from the American Insulator Corporation

COLD MOLDING COMPOUNDS

by S. PELLERANO*

GENERALLY SPEAKING, BY COLD MOLDING IS meant the process of molding powders under pressure in a die at room temperature. However, cold molding can also very well include such compositions as are used for battery boxes, which are kept plastic at a rather high temperature and later formed in a cold die. More specifically, however, and the subject of the present discussion, it is that process whereby the powders are formed into a coherent mass under pressure in a die at room temperature and subsequently heated in ovens to harden. In other words, this procedure is similar to that employed in the manufacture of clay and porcelain except that the final temperature employed in processing is not as high as that used in ceramics.

Composition and formulation

Cold molding powders are composed of a filler and binder. The filler usually consists of short asbestos fibers together with other minerals, such as clay, talc, slate-flour, barytes, and the like. It is also possible to employ an organic filler such as woodflour. The binders, the characteristics of which very largely determine the properties of the finished product, may be divided into these three main groups which are listed in the column which follows above.

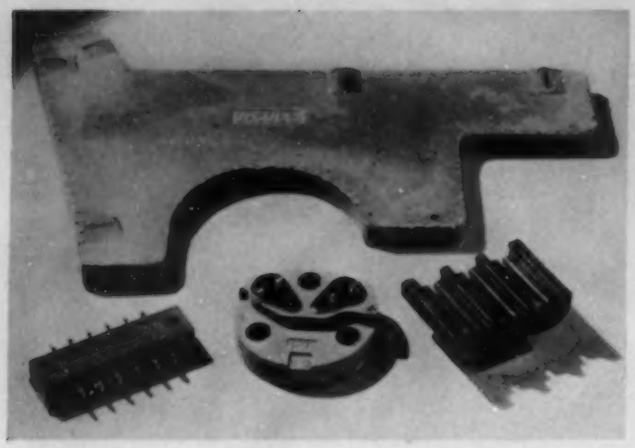
(a) Bituminous
(b) Synthetic Resins
(c) Inorganic (Portland cement, sand-lime, etc.)

These three types correspond to the German classification of Types 2, 3, 4 and X.

(a) *Bituminous binder.*—This consists of a varnish-like material formulated from various percentages of oils (linseed, tung, castor, oiticica, fish, etc.), natural and synthetic resins (coumarone, indene, copal, dammar, ester gum, etc.), and asphalts (gilsonite, steam-reduced and blown petroleum), together with stearine pitch or vegetable pitch. A selection of these materials are blended together and cooked somewhat in the fashion employed by the varnish maker. This combination is then cut with a thinner or solvent (or a mixture thereof—such as hi-flash naphtha, coal-tar naphtha, mineral spirits, gasoline and benzol) to obtain a heavy liquid of a definite viscosity, determined by the absorptive properties of the filler. The addition of a plasticizer, such as tricresyl phosphate, butyl stearate, dibutyl stearate and chlorinated diphenyl has been found to be of value in aiding plastification and improving the product's resistance to heat.

The binder, which comprises 25 to 30 percent of the finished powder, is added to short asbestos fibers (ranging from Floats to Canadian Classification of 0-0-5-11)

* Consulting Chemist.



Garfield Mfg. Co. turned out these typical cold molded plastic parts, which include electrical appliance parts and knobs for cooking utensils

together with fibrous talc, clay, red oxide, and vulcanizing or oxidizing agents such as sulphur, selenium, litharge and driers, and various modifying agents, in a kneading machine of the Werner-Pfleiderer type and mixed until a powder having the desired properties is obtained. It is of course essential to quality production that all manufactured powders be uniform in bulk factor, plasticity, particle size, etc. All these control tests should be made before the powder is approved for production utilization. After the material is released from the mixer it is graded and then conditioned by air-drying for a period of about one week so that sufficient solvent will have evaporated. The non-tacky compound thus obtained is now suitable for pressing. (There are several methods of eliminating or modifying this conditioning process so that production may be expedited considerably.) After proper aging, about 0.5 to 1 percent of a lubricant such as a metallic stearate or a neutral soap, is usually added to assist the molding operation. After compression molding in a hydraulic or toggle press, the articles are baked for about 24 hrs. at gradually increasing temperatures (e.g., 4 hrs. at 180 deg. F., 4 hrs. at 250 deg. F., 4 hrs. at 300 deg. F., 4 hrs. at 350 deg. F., etc.), to produce by polymerization, distillation or oxidation, or a combination of these, a final product of considerable hardness and possessing excellent chemical and dimensional stability upon prolonged exposure to temperatures of about 500 deg. F.

As an example of a typical cold molding powder composition we may cite U. S. Patent #1,671,230 (all parts on a weight basis):

	Stearine pitch	40 parts
	Asphalt	60 "
Binder:	Castor oil	10 "
	Benzol	25–100 "
	Asbestos	1100 parts
Filler:	Sulphur	66 "
	Iron oxide	22 "

This quantity of filler is used in combination with 286 parts of the binder described. In place of castor oil, linseed, tung or fish oil may be used. Gilsonite, steam-reduced or oxidized asphalt, or mixtures of these, may be substituted in all or in part for the stearine pitch. Driers such as litharge, naphthenates, or rosin may be added. Other solvents such as mineral spirits, hi-flash naphtha or gasoline may be used in place of benzol to yield a predetermined viscosity requirement.

(b) *Synthetic resin binder.*—A widely used binder consists of a viscous "A stage" phenolic resin of about 17 to 18 deg. Baumé gravity. A Werner-Pfleiderer or similar mixing machine is usually employed in mixing the binder and the filler (in this instance largely asbestos). The resulting powder is then molded and processed in the regular manner; the baking is generally of shorter duration than with bituminous binder. The powders formulated with synthetic resin binders are rather unstable and must be pressed shortly after being prepared.

(c) *Inorganic binders.*—Cold molding composition made with inorganic binders is known as the "refractory" type. The binders used are Portland cement (High Early-Strength being preferred) or lime and silica, together with asbestos, plastic or china clays, and proper amount of water to give sufficient flow and density to the piece when subjected to pressure in the mold. Moldings made with Portland cement binders are usually hardened by soaking in water or in a humidity chamber, whereas those containing sand-lime are processed in steam autoclaves. The finished products normally absorb 10 to 12 percent water. In order to reduce this to a minimum, they are impregnated with materials such as ceresin, amorphous waxes, creosote or pitches such as coal-tar. It is also possible to mix powdered coumarone-indene resin with the asbestos-cement-water mixture before molding. After the molded piece has been cured in water, it is baked in the usual manner in gas or electric ovens. During this operation the resin flows and renders the product impervious to water. In contradistinction to pitches, the articles impregnated with coumarone-indene in this fashion do not track when they are subjected to the electric arc.

Present status and future possibilities

Since the development of hot molding compounds, the use of cold molding materials has been greatly reduced. The principal reason for this unfortunate condition is that with the possible exception of one or two concerns who produce for their own use, very little attention has been devoted to development and research in this potentially important field. This lack of action has seriously hampered the progress of the industry as a whole and has virtually caused a stagnation period of 30 years. Cold molding must therefore be considered still in its infancy. Wherever a low-cost high-heat resisting electrical insulator is required, however, cold molding composition is still the logical choice.

Unlike hot molders, the cold molders all manufacture their own particular molding powders. This policy has heretofore been considered inevitable due to alleged instability of the powder. However, it is now possible to distribute and market stable cold molding powders in the same manner that hot molding powders are sold today. This revolutionary development coupled with the natural advantages of greater formula modification as well as more rapid production throws open a virgin field to a scientifically inclined manufacturer interested in the production and sale of standardized cold molding powders to molders throughout the country (who are at present already equipped with the necessary presses). As the curing operation is not performed in the die itself, the daily cold molding production rate is much higher than that obtained in hot molding. In addition, the employment of automatic presses and presses actuated by air or cam movements would further increase the production rate. Cold molding also possesses an economical advantage over hot molding when a short production run requiring a single cavity is specified.

Forms available

At present the only forms available are finished articles produced from cold molding compounds.

Typical applications

Bituminous—find wide employment in the manufacture of handles and knobs for cooking utensils, valve wheels and numerous other articles. One of the chief applications of bituminous cold molding powders is in the manufacture of connector plugs used on flat-irons, toasters, ranges, etc., where high-heat resistance is essential. The recently promulgated requirements of the Board of Fire Underwriters' for connector plugs presents a particularly fertile market for the progressive manufacturer of improved cold molding compounds.

Synthetic resin—used for miscellaneous electrical parts. Bituminous cold molded material does find use for electrical purposes but in some instances the water absorption is too high; bituminous material also contains water-soluble matter which is sometimes greatly undesirable. The synthetic resin cold molded type is far superior in this respect although improvement could be made in the bituminous type. Synthetic resins, other than the phenolic, should prove of value as binders for cold molding powders. The synthetic resin type has greater mechanical strength, is considerably tougher than the bituminous type, and can be made with a finish almost equal to that obtained in hot molding.

Inorganic—This type continues to be used where high-heat resistance (up to about 1000 deg. C.) and arc resistance are required. Arc shields, electric heating bases and certain special insulators, etc., demand this type.

Outstanding properties

Heat resistance
Low-cost raw materials
Rapid molding cycle

Trade names

Organic: *Aico, Cetic-Non-Refractory, Ebrok, Gummon, Okon, Thermoplax.*
Inorganic: *Aico-5, Alphide, Cetic-Refractory, Coltstone, Hemit.*

Handles for stoves and coffee makers made of cold molded materials resist greater heat than many of the hot molded compounds will withstand. Those below are by Cutler-Hammer, Incorporated

COLORING MATERIALS

by W. H. PEACOCK* and R. H. KIENLE**

BECAUSE PLASTICS VARY SO WIDELY IN CHEMICAL nature, physical condition, process engineering, uses and testing specifications, it has been found that no one coloring matter, or group of coloring matters is equally suitable for use in all. Usually each plastic, and frequently some specific use of a plastic, requires the cooperative study and service of the manufacturers of both the plastic and the coloring material. In fact, most of the color problems are being solved in this manner.

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** Director, Physicochemical-Research Laboratory, The Calco Chemical Co., Inc.

A comprehensive review of the coloring of plastics has already been given by the authors.[1] The coloring of cellulose esters plastics has been ably discussed by Clewell and Payne.[2] The use of white and other inorganic pigments has also been discussed by Richards.[3] The present paper is supplementary to these publications.

TABLE I. COMPATIBILITY OF COLORING MATERIALS WITH VARIOUS PLASTIC BINDERS

Type of Plastic Binder	Acid Dyes	Mordant Acid Dyes	Basic Dyes	Direct & Developed Dyes	Sulphur Dyes	Vat & Naphthol Dyes	Acetate Dyes	Spirit Soluble Dyes	Oil Soluble Dyes	Insoluble (Organic) Dyes (1), Lakes, Toners	Pigments Inorganic (1)
Acrylate	N(2)	N(2)	C(3)	N	N	C(1)	C(4)	C(1)	C	C(1)	C(1)
Alkyd	N(5)	N(5)	N(5)	N(5)	N	C	N(5)	N(5)	N(5)	N(5)	C(1) (3)
Casein	C	C	C	C	C	C	N(8)	N	N	C(1)	C(1)
Cellulose:—Acetate	N(2)	N	N(5)	N	N	C(1)	C(6) (4)	C	C	C(3) (1)	C(3) (1)
—Ethers - methyl ethyl-benzyl	N(7)	N	C(3)	N	N	C(1)	C(4)	C	C	C(1)	C(3) (1)
—Nitrate	N(7)	N(7)	C(3)	N(7)	N	C(1)	C(4)	C	C	C(3) (1)	C(3) (1)
Cold Molded: —Organic	N	N	N	N	N	N(7)	C(4)	N	C	C(1)	C(1)
—Inorganic	C	C	C	C	C	C(1)	N(2)	N(7)	N	C(1)	C(1)
Natural: —Water-soluble adhesives	C	C	C	C	C	C	N(2)	N	N	C(7) (1)	C(7) (1)
—Alcohol-soluble shellac, etc.	N(2)	N(2)	C(3)	N(2)	N	C(1)	N(2)	C	N(2)	C(1)	C(1)
—Hydrocarbon-soluble resins	N	N	N(2)	N	N	C(1)	C(4)	N(7)	C	C(1)	C(1)
Phenol-formaldehyde: —Molding powders	N(7)	N(7)	C(3)	N(7)	N	C(1)	C(4)	C(3)	C	C(1) (3)	C(1) (3)
—Laminating varnishes	N(5)	N(5)	N(5)	N(9)	N(9)	N(9)	N(7)	C	N(7)	C(1) (3)	C(1) (3)
—Cast	N(6)	N(6)	N(6)	N(6)	N(2)	N(7)	N(7)	C	C(6)	C(1) (3)	C(1) (3)
Phenol-furfural: —Molding powders	N(7)	N(7)	C(3)	N(7)	N	C(1)	C(4)	C(3)	C	C(1) (3)	C(1) (3)
—Laminating varnishes	N(5)	N(5)	N(5)	N(9)	N(9)	N(9)	N(7)	C	N(7)	C(1) (3)	C(1) (3)
Rubber: —Chlorinated	N	N	N(2)	N	N	C(1)	C(4)	N	C	C(1)	C(1)
—Hydrochloride	N	N	N(2)	N	N	C(1)	C(4)	N(7)	C	C(1)	C(1)
—Hard	N	N	N(2)	N	N	N(7)	C(5) (4)	N	C(5)	C(1) (3)	C(1) (3)
—Tire	N	N	N	N	N(10)	N(10)	C(5) (4)	N	C(5)	C(1) (3)	C(1) (3)
—Sponge	N(2)	N(2)	N(2)	N(2)	N	C(1)	C(2) (4)	N	C(2)	C(1) (3)	C(1) (3)
—Foam	N(2)	N(2)	N(2)	N(2)	C	C(1)	C(2) (8)	N	C(2)	C(1) (3)	C(1) (3)
—Latex	N(2) (7)	N(2) (7)	N	N(2) (7)	C	C(1)	C(2) (8)	N	C(2)	C(1) (3)	C(1) (3)
Styrene: —	N	N	N(2)	N	N	C(1) (3)	C(4) (6)	N(7)	C(6)	C(1)	C(1)
Urea-formaldehyde: —Molding powders	N(6)	N(6)	N(6)	N(6)	N	C(1)	C(6)	C	C(6)	C(3) (1)	C(1)
—Laminating syrups	C(6)	C(6)	C(6)	C(6)	C(2) (9)	C(1) (9)	C(8)	N(2)	N	C(1) (3)	C(1)
Vinyl resins: —Filled	N(2)	N(2)	C(5) (6)	N	N	C(1)	C(5) (4)	N(7)	C(5)	C(1) (3)	C(1)
—Unfilled	N(2)	N(2)	C(5) (6)	N	N	C(1)	C(5) (4)	N(7)	C(5)	C(1) (3)	C(1)
Waxes: —Mineral	N(2)	N(2)	N(2) (7)	N	N	C(1)	C(4) (3)	N	C(3)	C(1)	C(1)
—Vegetable	N(2)	N(2)	N(2) (7)	N	N	C(1)	C(4) (3)	N	C(3)	C(1)	C(1)
Affinity of the dyes	Direct for proteins	Direct for proteins & mordants	Protein, clays, & tannin-cellulose	Cellulosic materials, paper, cotton, jute, woodflour, rayon and grasses			Cellulose acetate fabrics	Color materials by absorption, dispersion or mechanical adhesion			

KEY—N = Not compatible, C = Compatible

Notes on suitability or method:
(1) Not truly soluble, but can be incorporated by dispersion, so rated as compatible by the trade.
(2) Some can be incorporated, but they are not generally suitable.
(3) Some are not suitable, may not be stable, or may affect stability of binder.
(4) Refers to the unblended dyes, not to the water-dispersible grades.
(5) A few are suitable, but most are unstable.
(6) Some are stable, but most are not fast enough to light.
(7) Some are suitable for special applications.
(8) Water-dispersible grades can be incorporated, but may not be stable or fast to tests (dry cleaning).
(9) Some are used on pre-dyed or printed fillers.
(10) Purified grades are used on the tire fabrics.

Chemical nature

There are about 1400 chemical compounds in the dye trade lists, and literally thousands of their mixtures, that can be used as coloring matters for the binders and fillers of plastics. It is impractical to discuss them individually. Chemically, they have been classified with reference to their chromophoric nuclei, into such groups as nitro, azo, azine, tri- and di-phenylmethanes, xanthine, sulphur, anthraquinone, inorganic, and many others.[2] In most cases the chemical constitution of a dye, and its stability in plastics cannot be correlated. Therefore, for dye users, a classification based on application properties has been employed in the attached tables.

General characteristics

Where solubility or ultimate compatibility of the coloring material and binder is sought, the following remarks may serve as a general guide. Acrylate, rubber, styrene, vinyl, natural resins and wax type plastic require ketone-, oil- and hydrocarbon-soluble dye. Cellulose esters and ethers, shellac and spirit varnishes for laminating work call for alcohol-soluble dyes. Cast phenolics, urea syrups, protein glues and casein, vegetable gums, carbohydrate, silicate and Portland cement adhesives usually are colored with water-soluble or water-dispersible dyes. Molding-powder plastics may be colored with soluble dyes, insoluble dyes, lakes and pigments, although to varying advantage. The coloring of the fibrous fillers involves all the dyes and processes in use in the textile and paper trades.

During 1938–1939 the color influence of the New York and San Francisco Fairs has been felt in the plastics field. More specific developments concern the recent extended uses of acrylate, polystyrene and vinyl resins; the successful dyeing of molded urea-ware to assist flow studies and obtain unique decorative effects, and the development of pastel-colored coating enamels for dark-bodied phenolic plastics. Many color problems have arisen with the considerable increase in use of both heat-convertible and non-heat-convertible synthetic plastics in the textile and paper fields, such as in the crease-proofing[4] and resin-printing of textiles,[5] and in the hot-melt coating processes for paper.[6] Additional problems have resulted in connection with the recent widespread use of injection molding equipment. Cooperative research has been effective in solving these specific problems.

Properties of coloring materials

In Table I there has been summarized, for ready reference, the compatibility of the several classes of coloring materials with the binders more commonly used in plastics. Other properties of interest have been summarized in Table II.

Trade names

More than 4500 trade names for dyes used in the United States are published yearly.[7]

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1. The Coloring of Plastics, W. H. Peacock, R. H. Kienle, Modern Plastics, Oct. 1936.
2. The Use of Pigments, Lakes and Other Coloring Materials in Plastics, J. H. Clewell & H. W. Payne, Ind. Eng. Chem., **29**, 750 (1937).
3. Colour Index, Soc. Dyers & Colorists, Bradford, Eng., 1924 and 1928 Suppl.
4. A. E. Battye, J. T. Marsh, J. Tankard, W. H. Watson, F. C. Wood (Tootal Broadhurst Lee Co.), U. S. P. 2,088,227; C. A. Amick, American Dyestuff Reporter, **24**, 553, 622, 645 (1935); Powers, American Dyestuff Reporter.
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6. Thermoplastic Coatings—A New Approach to Decorative Paper, J. H. Long T.A.P.P.I. Convention, N. Y., Feb. 1939.
7. Year Book—American Ass'n Textile Chemists and Colorists.
8. Colours and Pigments for Plastics, Chemistry and Industry, Jour. Soc. of Chemical Ind., London, **55**, 23, June 1936.

TABLE II. GENERAL PROPERTIES OF COLORING MATERIALS USED IN PLASTICS

Type	Affinity	Hue	Solubility			Dispersibility in Resins	Fastness Properties				Uses
			Water	Alcohols	Hydrocarbons		Heat	Aldehydes	Light	Alcohol & Water	
Acid Dyes	Direct for proteins	Bright and strong	Good	Sparingly	Insol.	Generally poor, varies with dye and conditions	Mod. Mod.	Varies	Good	Bleed	Protein plastics, cast phenolic, urea resins and water sol. binders
Mordant Dyes	Direct for proteins	Somewhat dull	Good	Spar.	Insol.	Generally poor	Mod.	Varies	Very good	Bleed	Same as acid dyes
Basic Dyes	Proteins, certain clays high Tannin Cellulosic materials	Very bright and strong	Good	Good	Insol.	React with many resins Good	Mod. some reds are good	Varies	Poor	Bleed	Can be applied to most plastics
Direct & Developed Dyes	Cellulosic materials	Somewhat dull	Good	Spar.	Insol.	Generally poor	Mod.	Varies	Mod.	Bleed	Used to color cellulosic fillers
Sulphur Dyes	Cellulosic materials	Dull	Sol. in Na_2S solutions	Insol.	Insol.	Poor	Mod.	Good	Good	Good	Used chiefly for rubber tire fabrics and trubenized cloth
Vat Dyes	Cellulosic materials	Somewhat dull & weak	Sol. in alkaline reducing solutions	Insol.	Insol. (Bleed)	Moderate	Mod.	Varies	Very good	Good	Useful in many plastics but they are expensive
Acetate Dyes	Cellulosic acetates	Bright	Insol.	Spar.	Varies	Moderate	Good	Varies	Mod.	Bleed	Cellulose acetate fabrics
Colors and Lakes	All materials by adhesion	Bright	Insol.	Insol.	Insol.	Good	Good to mod.	Varies	Mod. to good	Many bleed	Resins and cellulose esters
Pigments	All materials by adhesion	Soft toned, dull	Insol.	Insol.	Insol.	Good	Good	Good	Very good	Good	All opaque plastics
Spirit-Soluble Colors	All materials by absorption or adhesion	Bright & strong	Many are sol.	Sol.	Spar.	Good	Varies	Varies	Varies	Bleed	Most plastics
Oil-Soluble Colors	All materials by absorption or adhesion	Bright & strong	Insol.	Spar.	Good	Good	Good	Good	Mod.	Bleed	Resins and cellulose esters

ETHYLCELLULOSE

by D. R. WIGGAM*

CELLULOSE DERIVATIVES, PARTICULARLY THE esters such as the nitrate and the acetate, have long been utilized in the fields of plastics and protective coatings because they possess the properties of toughness and thermoplasticity. Ethylcellulose is a comparatively new cellulose ether which recently has been made available commercially in this country. It possesses to an unusual degree the properties of toughness and thermoplasticity, a low order of flammability, and has formulation flexibility. This combination of properties has stimulated a widespread interest in its use.

Chemistry of formation

Cellulose is conceived to be composed of long chain molecules, the building units of which are glucose residues having the empirical formula $C_6H_{10}O_5$. Each such unit has three available hydroxyl groups which can be substituted. Fig. 1 shows the configuration of a group of four of these theoretical units. Ethylcellulose is a cellulose ether in which ethyl groups have replaced the hydrogens in the hydroxyl groups of the glucose residues. The standard ethylcellulose available commercially has been substituted to the extent of 2.4 to 2.5 ethoxyl groups per glucose residue.

It is prepared by treating cellulose, such as wood pulp or cotton linters, with a strong aqueous solution of sodium hydroxide. This causes the formation of alkali cellulose which is then alkylated with such reagents as ethyl chloride or sulfate. The operating conditions are carefully controlled in order to prevent undesirable degradation of the cellulose and destruction of the alkylating agent. After etherification is complete, the excess reagents are removed by washing and distillation. Ethylcellulose is easily purified by washing the product free from soluble materials.

* Hercules Powder Co., Inc.

General characteristics

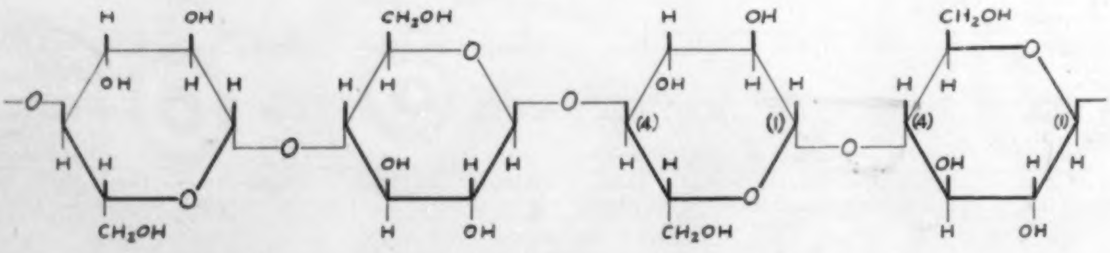
Ethylcellulose containing 2.4 to 2.5 ethoxyl groups, and within this range of substitution material of 47 to 48 percent ethoxyl content, possesses the widest variety of useful properties. The properties of unusual toughness coupled with thermoplasticity and low flammability have been mentioned above. The unplasticized material is flexible at temperatures as low as −40 deg. C., and it is very extensible. Because of these facts, ethylcellulose compositions possess a degree of low temperature toughness not found in other thermoplastic materials. It burns about like cellulose acetate and the products of combustion are harmless gases. The maximum advantage can be realized from the thermoplastic character of ethylcellulose because it is also stable to heat. Its inertness to alkalies of all strengths and to dilute acids could be deduced from its ether structure; likewise, its solubility and compatibility with a wide variety of solvents, resins, waxes, oils, and plasticizers could be predicted. It has a moisture absorption of 2 percent which is somewhat better than cellulose acetate and slightly poorer than nitrocellulose. Bass and Goggin[1] have shown that ethylcellulose film and molded plastics, are excellent electrical insulating materials.

The specific gravity of 1.14 for ethylcellulose compares with 1.37 for cellulose acetate and 1.60 for nitrocellulose. This low value has special significance because it means that 1 lb. of ethylcellulose will produce as many plastic articles as 1.20 lbs. of cellulose acetate and 1.40 lbs. of nitrocellulose. This same advantage holds for films, protective coatings, adhesives, etc.

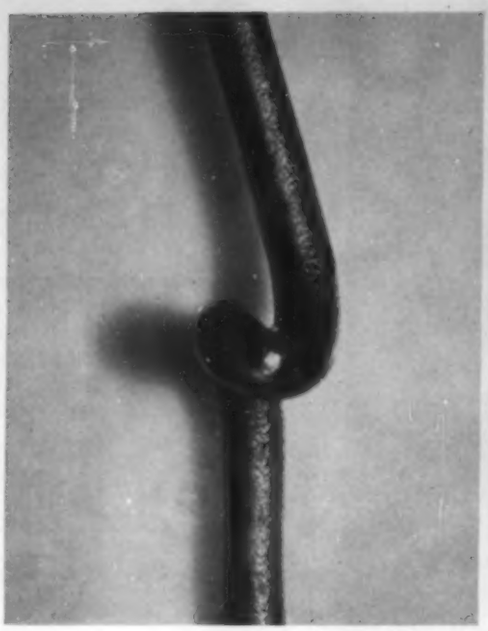
Straight chain petroleum hydrocarbons comprise the only class of organic liquids which do not exhibit marked

1. Shailer L. Bass and W. C. Goggin, Transactions of The Electrochemical Society, Vol. LXXIV, pp. 47–65, October 13, 1938.

Fig. 1



THEORETICAL CONFIGURATION OF A PORTION OF A CELLULOSE MOLECULE.



Ethylcellulose plastics have been formulated by proper plasticization so, in the form of extruded insulation, they resist the tendency of wire to cut through the insulation at elevated temperatures of usual usage. The wire at the left was kinked tightly at 40 deg. C. but the ethylcellulose insulation did not crack. (Photos, courtesy Hercules Powder Co., Incorporated)

solvent action on ethylcellulose. An exceptionally good solvent combination, which is also economical, is composed of 70 to 80 parts by weight of an aromatic hydrocarbon, such as toluene, or a hydrogenated naphtha, such as Solvesso, with 30 to 20 parts by weight of an aliphatic alcohol, such as denatured ethyl alcohol. The available plasticizing agents are practically unlimited and cover such widely divergent classes as high boiling esters, raw oils, air-blown oils, fatty acids and chlorinated diphenyl derivatives. Heat-bodied oils usually are considered as incompatible but can be used in limited quantities, especially in the presence of a mutually compatible third ingredient. Useful waxes include the usual ester type waxes, both vegetable and animal, and many bituminous materials such as montan wax, coal-tar, stearin pitch, etc. Paraffin in the presence of a mutually compatible third ingredient can be used in appreciable quantities, but alone it is incompatible with ethylcellulose. Compatible resin classes encompass many of the natural resins including all of the alcohol soluble types, pure phenolics, rosin modified phenolics, rosin modified maleates, long oil or fatty acid extended alkyd resins and some miscellaneous types such as ester gum. Many hydrocarbon, urea-formaldehyde, short oil-modified alkyd and oil-modified phenolic resins exhibit limited compatibility, but are quite useful in ethylcellulose compositions in which the amount of resin employed is relatively low. Again, the principle of employing a mutually compatible third ingredient, such as a plasticizing agent, is often effective in overcoming the tendency for incompatible mixtures to form.

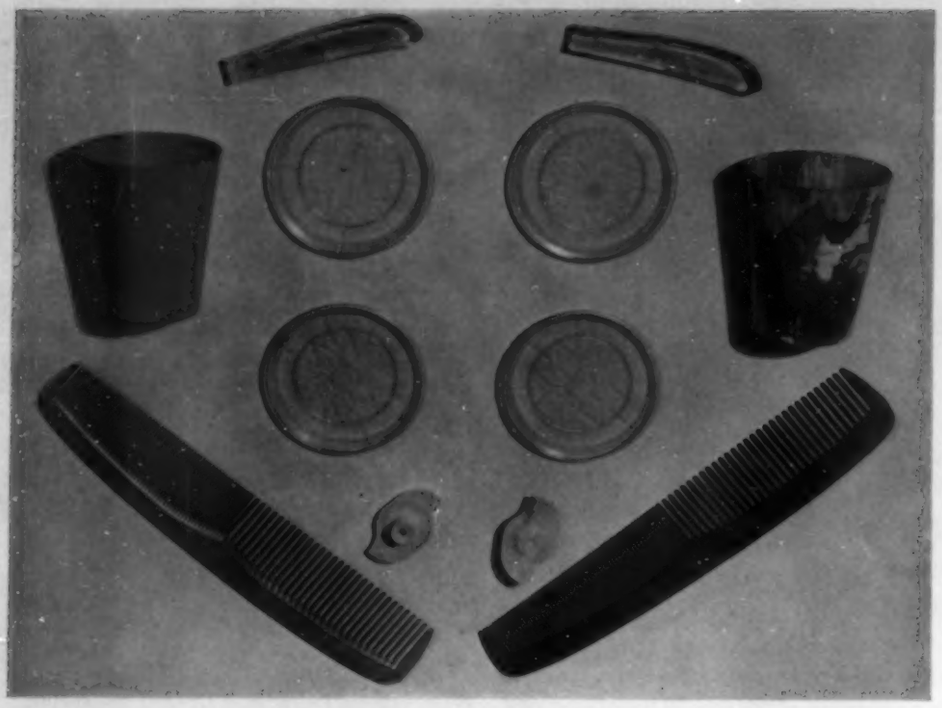
Ethylcellulose dissolves readily in hot resins, oils, waxes, plasticizers and mixtures of these in the absence of any volatile solvent. Since such compositions are very thermoplastic, they can be applied as molten mixtures at elevated temperatures and form the bases for adhesives, coatings, and the like.

Developments during 1939

The suitability of ethylcellulose for use in plastics was discussed in an article by Wiggam[2] in the October 1936 issue of Modern Plastics. In the October 1937 issue, Gibb[3] discussed some ethylcellulose plastics and the general method of preparing them. These earlier articles were confined to mixtures of ethylcellulose and plasticizers. Wiggam and Koch[4] brought out the advisability of using resins in ethylcellulose plastics in the October 1938 issue. Since then, decided progress has been achieved in the development of successful ethylcellulose extrusion wire coatings, and injection plastics containing resins. In both of these fields of development there has been striking evidence that both formulation and application technique play very important roles in the successful use of ethylcellulose plastics.

For example, ethylcellulose plastics modified with the usual solvent type plasticizers are unsuited for use as extruded wire insulation because the wire cuts through the insulation under the usual conditions of use. However, ethylcellulose plastics have been formulated by proper plasticization which, in the form of extruded insulation, resist indefinitely the tendency for the wire to cut through the insulation under the usually elevated temperatures of customary usage. Electrical characteristics of this insulation are good. (*Please turn to next page*)

2. D. R. Wiggam, Modern Plastics, p. 31, October 1936.
3. D. A. Gibb, ibid., p. 23, October 1937.
4. D. R. Wiggam and William Koch, ibid., p. 28, October 1938.



A variety of moldings of ethylcellulose submitted by Hercules Powder Co., Inc., to indicate the versatility of the compound which, as you can see, may be mottled, dyed or clear

These plastics, if applied properly, not only are resistant to flow at elevated temperatures under stress, but are also very flexible at a temperature of −40 deg. C. On the other hand, improper application results in extremely brittle extruded coatings. Successful application depends upon extruding the compositions heated to approximately their melting points around wire preheated to a similar temperature.

Injection plastics have been developed by proper selection of resins and plasticizers which are exceptionally resistant to water absorption, are hard, very resistant to shock and have good resistance to cold flow. The inclusion of resin into ethylcellulose injection plastics has made possible compositions with much lower water absorption characteristics than is possible with plasticizers alone. Hardness and rigidity or permanence of dimensions are also greatly improved by the use of resins. Examination by polarized light indicates that commercially injected pieces are practically free of strain lines. This is important because it signifies very good uniformity throughout the injected article.

Forms available

Standard ethylcellulose of 47 to 48 percent ethoxyl content is available in the form of fine white granules in the following standard viscosity types.

5% Solution Capillary Viscosimeter	20% Solution 5/16 inch Falling Ball 10 inch Drop	Usual Designation
10 Centipoise	2 Seconds	XX Low viscosity
13- 16 "	3- 4 "	X Low "
24- 28 "	6- 8 "	Low "
45- 57 "	20- 30 "	Medium "
83- 99 "	60- 80 "	High "
190-240 "	200-300 "	X High "
270-300 "	400-500 "	XX High "

Viscosity is measured in a toluene and alcohol mixed solvent composed of 80 parts toluene and 20 parts denatured ethyl alcohol (by weight) at 25 deg. C.

Besides the standard types, ethylcellulose can be furnished in other degrees of substitution than 47 to 48 percent in any of the usual viscosity types indicated.

Methods of fabrication

Ethylcellulose plastics can be completely processed in 15 to 30 minutes on hot two-roll mills or in heated masticators of the Banbury type without the use of volatile solvents. Seasoning is thus unnecessary and there is very little "stock-in-process" at any one time. These plastics can be injection and compression molded and extruded from dies. Existing equipment for handling thermoplastics can be used without modification.

Compression molding requires approximately 275 to 325 deg. F. and 2000 to 4000 lbs. per sq. in. Both injection and extrusion operations require approximately 325 to 425 deg. F.

Typical applications

Protective coatings
Adhesives
Pigment grinding base
Extrusion wire insulation
Injection plastics
Cable lacquers
Hot-melt paper and cloth coatings

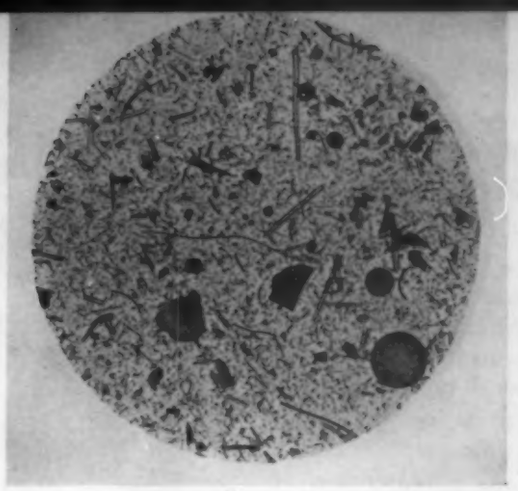
Outstanding properties

Unusually good low temperature flexibility and toughness
Wide range of compatibility
Stability to heat
Thermoplasticity
Electrical resistance

Trade names

Dow Ethocel, Hercules Ethylcellulose.

Photomicrographs of (Fig. 1) Filter-Cel, one of the Celite filter aids at 300 times actual particle size, and (Fig. 2) of Celite Snow Floss at exactly the same magnification



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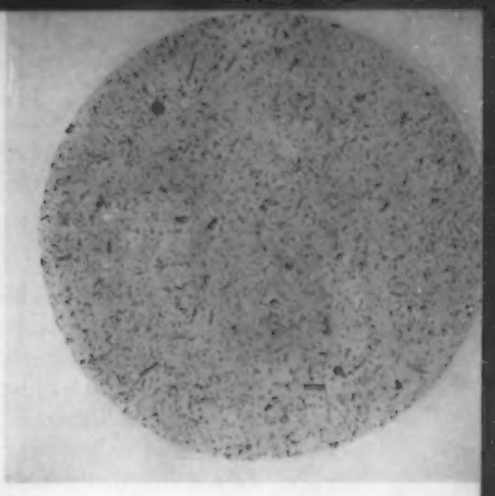

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FILLERS—ASBESTOS AND DIATOMACEOUS SILICA

by A. B. CUMMINS*

TWO OF THE MORE IMPORTANT MINERAL OR inorganic fillers employed in the plastics industry are asbestos and diatomaceous silica. Mineral fillers are required where high heat resistance, exceptional electrical properties or minimum moisture absorption characteristics are required in molded products. In addition, there are other characteristics of each of these fillers that make their use important in the plastics field.

Chemical composition

The term asbestos has now come to include most of the more or less fibrous minerals. However, as employed in the plastics industry, asbestos usually refers to the mineral *chrysotile*. This is a hydrated magnesium silicate, corresponding in composition fairly closely to the formula $H_4Mg_3Si_2O_9$ or $3MgO{\cdot}2SiO_2{\cdot}2H_2O$. Asbestos is employed in the form of fabric, paper and definitely fibrous forms for laminated compositions, etc., but its general use as a filler is as asbestos *fines* or floats, consisting of very fine fibers with associated dust and non-fibrous asbestic material.

Diatomaceous silica is a natural occurring opaline silica, containing three to eight percent of combined water and some two to six percent of other substances in chemical combination (alumina, iron oxide, alkaline earths and alkali metals). The material is of plant origin, consisting of the silicified residues of diatoms, which are microscopic aquatic plants of common occurrence. Diatomaceous silica is unique among mineral fillers because of its microscopic structure, great bulk, high absorptive capacity and low specific gravity.**

Chemical analyses for samples of *chrysotile* asbestos from Quebec and Arizona and of a leading grade of commercial diatomaceous silica are given in Table I:

TABLE I

	Chrysotile Canadian	*Chrysotile* Arizona	Diatomaceous Silica *Celite*
Moisture (Loss at 100° C.)	1.88	0.69	0.30
Combined H_2O (Loss on ignition)	13.60	13.86	0.22
SiO_2	39.91	42.69	92.42
Al_2O_3	1.35	0.39	3.86
Fe_2O_3	2.05	0.63	1.35
MgO	41.57	41.73	0.60
CaO	Trace	0.20	0.28
Na_2O	....	....	1.01
TOTAL	100.36	100.19	100.04

General characteristics

Asbestos. The only natural fibrous material of mineral composition available. Its use is required when a fine fibrous filler must be used for temperature conditions above that which can be tolerated by the usual organic fillers, such as woodflour, cellulose, etc., which char at temperatures below that at which any apparent change occurs with asbestos.

The specific gravity of pure *chrysotile* may be as low as 2.25, but for commercial grades the range will be ordinarily from 2.45 to 2.80. Color varies from nearly white to gray. Heat resistance is good to above 1400 deg. F. Dry density of commercial grades varies from 12 to 40 lb. per cu. ft. Fineness specifications vary widely. Fiber length in all materials used as a powdered filler is below $^1/_8$ inch.

Diatomaceous Silica. Its true specific gravity is within the range of 2.0 to 2.3. Apparent density (dry) is 8.0 to 25.0 lbs. per cu. ft. Fineness specifications range between zero percent on 200 mesh to ten to fifteen percent on 150 mesh depending on the use. While diatomaceous silica has an extraordinarily high absorptive capacity for

* In charge of Celite research, Johns-Manville Research Laboratories.
** Diatomaceous Silica in Plastics, Modern Plastics, October 1936.

liquids, etc., it is readily mixed with plastic compositions and can be handled satisfactorily in molding operations.

Developments during 1939

Asbestos. Greater effort has been made on the part of manufacturers to effect standardization of grades and to provide new and improved grades than in any previous year. At least one of the leading asbestos producers has carried out extensive technical investigations on the grades of fiber most suitable for different purposes and has set up a continuous technical service group to meet the requirements of the plastics trade, both in supplying the proper grades of short-fiber filler and in developing the best technique and methods in the use and application of asbestos in molding powders.

Some outstanding advances during 1939 have been:

1. Production of necessary grades now standardized at economic price levels.
2. Commercial availability of cleaner and better short-fiber grades.
3. Establishment of expert technical service.

Diatomaceous Silica. The use of diatomaceous silica in synthetic plastics is relatively new, but has been definitely increasing. During 1939, the increase in use came to nearly 100 percent over the average for the previous four year period. This has come about through wider acquaintance with the unique properties of diatomaceous silica and recognition of some of the outstanding qualities of molded objects filled with this inorganic material. Two outstanding developments have taken place in 1939:

1. The practical solution of problems in the fabrication of molding powders containing high loadings.
2. Introduction of certain new grades of material which are characterized by more ready mixability.

Types of products in which employed

Asbestos	*Diatomaceous Silica*
Heater plugs	Battery boxes
High heat-resistant parts, irons, ovens, etc.	Phonograph records
	Heater plugs
Electrical panels	Sulphur plastics
Flooring compositions	Electrical parts
Laminated products	Closures
Electrical insulations	Surgical parts
Wax compositions	Asphaltic cements and enamels
Roofings	
Friction materials	Rubber products
"Haveg" type compositions	Box toe compositions
Coating compositions	For many parts requiring excellent and durable surface finish
	Phone receivers
	Precision molding

Forms available

Asbestos	*Diatomaceous Silica*
Long fiber	Natural powders and calcined powders of different degrees of fineness and chemical purity
Short fiber	
"Floats"	
Fabric	
Yarn	Different density materials available from very light powders to those of 25 lb. per cu. ft. loose weight
Paper	
Low iron-content grades	

Outstanding characteristics as fillers

Asbestos	*Diatomaceous Silica*
High heat resistance	High heat resistance
Chemical inertness	Chemical inertness
Low moisture absorption	Minimum moisture absorption
Low shrinkage	
Low coefficient expansion	Lowest specific gravity of any mineral filler
Fair electrical properties	Exceptional surface finish
Permits high loadings	Excellent electrical properties
High impact strength (with better quality grades)	Good to exceptional surface hardness
	Good molding flow
	Grit-free grades available

Trade names

Asbestos	*Diatomaceous Silica*
1. *Chrysotile*	1. *Infusorial*
a. Canada	2. *Kieselguhr*
b. Arizona	3. *Diatonite*
2. *Amphibole*	

A close-up of one of the huge cliffs of diatomaceous earth at Lompoc, Cal., showing the great depth and uniformity of the deposit. (Photo, courtesy Johns-Manville)

FILLERS—COTTON FLOCK AND WOODFLOUR

by VIRGIL E. MEHARG*

PREVIOUS ARTICLES OF THIS SERIES[1] HAVE dealt with reasons for filler use, the properties imparted to thermosetting resins by fillers, and the particular advantages and disadvantages of various individual fillers. The use of fibrous materials in the preparation of thermosetting plastic molding materials is shown to be unique, in that the filler imparts considerable strength to the molded product. Thus, varied properties are possible in thermosetting materials by virtue of filler selection as well as resin selection. This helps considerably in explaining the well-known versatility of these materials.

In this article we deal with two of the most used fillers, namely, *woodflour* and *cotton*. These two fillers are far more widely used than any others in thermosetting resins. Of the two, woodflour is used in much larger volume. The reasons for this have been amply set forth in a previous article.[2] Again, reference should be made to this article for the particular methods necessary to produce the proper fibrous type of woodflour—methods which have evolved over a period of years. Essentially, the wood must be defibered by shearing as contrasted with a strictly cutting operation. In other words, as far as possible the defibering operation must take place in such a manner as to preserve the fibrous structure to the maximum degree. Thus, the maximum strength of this fiber is imparted to the finished molded part.

Cotton, being already in a fibrous condition, the problem is one of cutting to the desired mesh and bulk factor. This term *bulk factor* will be explained more fully later, but it should only be noted here that while wood is sheared or ground, cotton is cut to give these filler materials their best properties for molded plastics.

Woodflour and cotton may be obtained in approximately the same mesh. In this finely ground condition, cotton is called *flock*. The presence of foreign materials, such as metallic scrap, is equally objectionable in either filler. Even organic materials, which will not absorb dye, will show up in the finished molded part, causing rejections. Therefore, they must be excluded from the raw material.

Both fillers are available in different shades of color, adaptable to use in producing molded parts of different color. Naturally, the lighter shades command somewhat higher prices. We must of necessity confine ourselves to phenolic compositions, since woodflour-filled products from urea resins have not yet been released commercially in this country.

Considering phenolic base molding materials, let us consider Table I to learn why woodflour commands so much greater use than cotton. (*See page 54.*)

Most large scale jobs today do not charge molds with powder, but instead, use preforms. This *preforming* is carried out in automatic machines, and to work successfully, it requires a *free flowing* powder. Cotton-filled molding materials are likely to be deficient in this respect.

To sum up, it may be seen that, for the molder, the use of cotton-filled molding materials presents problems. Usually, he cannot employ automatic preforming machines and must resort to weighing the charges for each mold cavity or use some other laborious measuring procedure. Either way entails more labor and expense. Molds must also be designed with a higher volume content to accommodate the cotton-filled material.

The molded specific gravity difference between cotton and woodflour filler is slight. The difference favors woodflour. The generally accepted specific gravity values are 1.36 for woodflour-filled materials, and 1.40 for cotton-filled materials.

In Table I, some of the terms require explanation. By the *apparent density* is meant density of the molding powder in a form ready for charging to the mold. The lower the apparent density of the powder, the deeper must be the mold cavity (if powder is charged to the mold). This is of some importance in cost of dies.

The ratio between the volume of molding material and the volume of the molded piece produced from this same volume of powder is called the *bulk factor*. It may be seen that it is the same as the ratio of molded density to apparent density. Bulk factor and apparent density are, therefore, related. In general, it is desirable to have a

* Research & Development Laboratories, Bakelite Corp.

1. Why Fillers in Thermosetting Molding Materials?—Modern Plastics, Oct. '37, p. 46. Filler Requirements,—Modern Plastics, Oct. '38, p. 30.

2. Modern Plastics, Oct. '38, p. 30.

1

2

Fig. 1 shows a common grinding of woodflour in which the particles are generally straight. Fig. 2 shows how cotton flock exhibits a tendency to curl. Microphotograph No. 1 is 175 magnification. All others are 150 magnification

3

4

Figs. 3–4 show microphotographs of typical molding material particles in which woodflour and cotton flock, respectively, were used as fillers

high apparent density (which means a low bulk factor). Cotton, as a filler, is at a disadvantage, compared with woodflour, in this respect.

Since the bulk factor of the molding powder is related to some extent to the bulk factor of the filler, the method of cutting or grinding the filler to obtain the best properties in the filler itself is important. This is especially true of cotton, which tends to give high bulk factors.

Reference to microphotographs may give a better conception of why this occurs. Fig. 1 shows a common grinding of woodflour. In general, the particles are straight. In Fig. 2, cotton flock shows a tendency to curl. The cotton fibers are smaller in diameter and longer in length.

Figs. 3–4 show microphotographs of typical molding material particles in which woodflour and cotton respectively were used as fillers. Although some evidence of original fiber is seen in Fig. 3, the cotton in Fig. 4 is very evident. It can readily be seen that powders comprising particles such as those in Fig. 4, would be bulky.

Up to this point, the comparison has been in favor of woodflour. In subsequent comparisons, the advantages of cotton will be discussed. The tensile, impact and flexural strengths of cotton-filled materials are, on the average, consistently better than woodflour-filled materials. The values, mentioned in Table I, are for the two fillers when cut to approximately the same mesh. Values somewhat higher than those given for cotton can be obtained if longer fiber length is used, but again, the gain will be at the expense of a poorer bulk factor and other related properties.

No doubt, some of the superior strength properties of a cotton filler are due to the inherent greater strength of the cotton fiber over the wood fiber. By a parallel lining up of relatively long fibers of cotton, surprisingly high values may be obtained in impact and flexural values in the direction perpendicular to the fibers. This is similar to the grain strength in wood. This may be of some use for such applications as aircraft construction. It is, of course, necessary to know the direction and magnitude of the stresses to take advantage of this special technique.

The properties already given immediately suggest the uses to which molding materials of the two filler types will be placed. Because of their ease of handling, low price and general adaptability to a wide variety of demands, the woodflour-filled materials are used wherever possible. On the other hand, where maximum tensile and flexural strengths are needed along with improved impact strength, the more expensive cotton-filled materials have a distinct advantage.

TABLE I

COMPARISON OF PROPERTIES

Properties of interest to molders

Apparent density of powder	— Lower for cotton filled
Bulk factor of powder	— Higher for cotton filled
Preformability of powder	— Poorer for cotton filled
Molded density	— Wood filled 1.36—Cotton filled 1.40
Flow range	— Approximately the same

Properties of interest to ultimate consumers

	Wood Filler	*Cotton Filler*
Tensile strength, lbs./sq. inch (molded plastic part)	7000–10,000	8000–12,000
Impact strength, ft. lbs. energy to break (molded plastic part)	0.11–0.20	0.20–0.5
Flexural strength, lbs./sq. inch (molded plastic part)	8500–12,000	10,000–14,000
Electrical properties (molded plastic part)	Equivalent for same resin.	

Cost

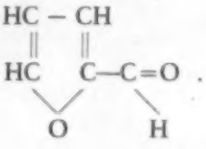
The basic cost of cotton filler is of the order of 4 to 8 times higher than woodflour. This higher raw material cost, plus the greater processing costs, means unavoidably higher price to the ultimate user. However, the increased strength properties very often outweigh these considerations. This has led to an increasing use of cotton. With decreasing costs, as volume goes up, it is confidently believed that the plastics industry will make increasing use of cotton in order to take advantage of its high-strength characteristics.

FURFURAL-PHENOL RESINS

by E. E. NOVOTNY*

THE FURFURAL-PHENOL RESINS ARE THE RESINous reaction products prepared by reacting furfural with phenolic bodies of various types, under carefully controlled reaction conditions. A wide variety of these resins are commercially produced, adapted to a great number of different fields of usefulness. The furfural-phenol resins were developed by the author and put into commercial production in 1920, and since that date new developments leading to new uses have gone on continually at an increasing rate. Although the most familiar of these products are the potentially reactive or heat-setting resins, widely used in the molding industry, other varieties including resinous liquids used for example for wood impregnation, and permanently fusible or thermoplastic varieties are also being manufactured.

Chemistry of their formation

The structural formula of furfural is  .

It will be noticed that there are three double bonds, and starting with the oxygen of the aldehyde group, these double bonds are arranged as a conjugated system. Since such a system constitutes a resinophore group it is in a large measure responsible for the ability of the furfural to condense with itself to form resinous products. The furane ring is quite stable.

In the reaction of furfural with phenols, the aldehyde group plays an important initial part. However, after the furfural has reacted with the phenol to form the initial reaction product, the furane ring with its conjugated system of double bonds also plays an important part, since it aids in providing a network of thoroughly interlaced, cross-linked molecular chains. The long molecular chains, capable of forming many cross-linkages or *cross polymerization*, provide products capable of complete cure, high strength and exceptional impact resistance. Since the double bonds largely disappear during cross polymerization, and the molecular weight of furfural is relatively high, there is a minimum number of points of attack so that fully cured pieces are chemically inert, and retain polish and rigidity even at high temperatures and molded pieces can be ejected at top molding temperatures without deformation or appreciable loss of dimensions. The presence of the furane ring in combination with the aromatic ring structure of the phenol produces a unique, long drawn out, flat plasticity curve, resulting in unusual flow characteristics, which has made injection molding of thermosetting resins a commercial reality. Since furfural is substantially anhydrous, and has a low water solubility, the mol of water resulting from the reaction of mol proportions of furfural and phenol may be continuously removed from the vapors during the reaction by a gravity separator so that the reaction is anhydrous, with the result that furfural resins of an anhydrous nature are readily produced. Furthermore, the reaction may be so carried out as to produce very stable dark colors that are inherent in the furfural-phenol resin itself.

* Durite Plastics.

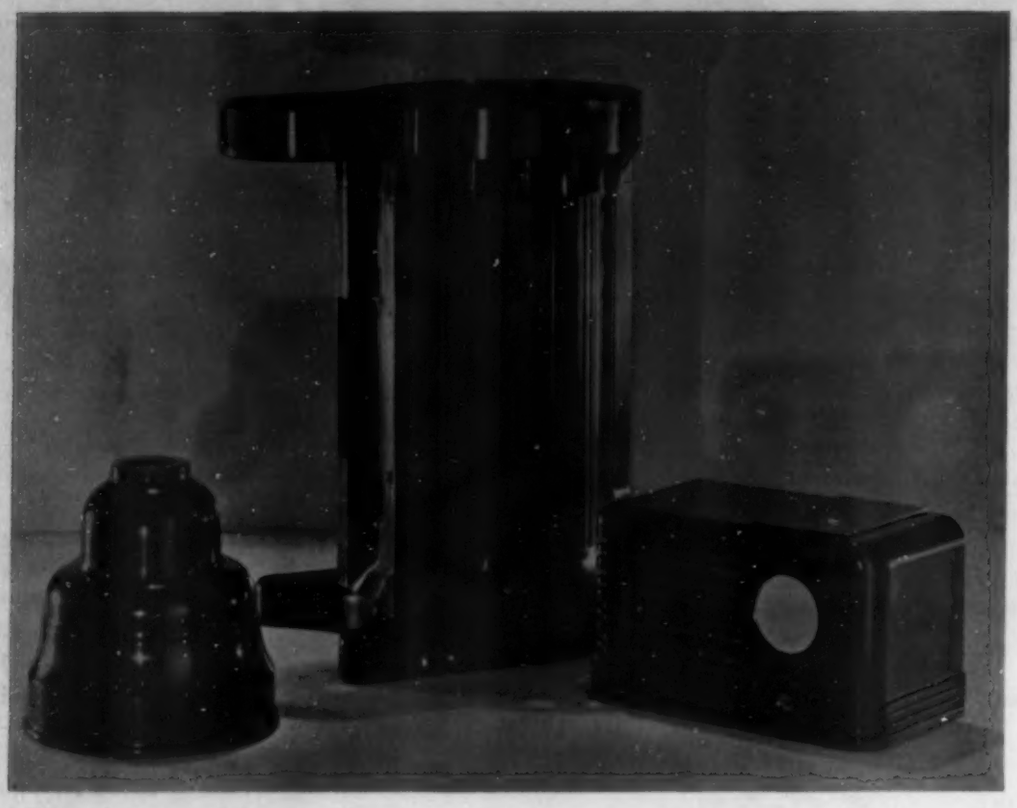
General characteristics

An outstanding characteristic of the furfural-phenol thermosetting resins is their flat plasticity curve. This means that in molding, the composition flows readily under most difficult molding conditions without segregation from the fillers which makes them admirably suited for the molding of difficult long flow or large parts, and provides great latitude in the molding of the most difficult work.

The furfural-phenol resins as ordinarily used do not go through the characteristic *A*, *B*, and *C* stages of the phenol-formaldehyde resins. The ring structure of furfural inhibits gelation, so that the rubbery, non-flowing *B* stage is avoided, and the resins maintain their flow characteristics at temperatures just slightly above temperatures required to induce plasticity over relatively long periods of time. As a matter of fact, molding compositions made from these resins may be kept in a heated reservoir under pressure for relatively long periods, and injected from the reservoir into a closed mold cavity in continuous injection molding. In actual injection molding operations the potentially reactive furfural-phenol resins have been kept sufficiently plastic for a period of 45 min. to inject and mold continuously. It is therefore not necessary to confine injection molding to thermoplastic materials.

On the other hand, at temperatures of 350 to 375 deg. F., a very rapid exothermic cure takes place. The furfural-phenol resins therefore provide a basis for molding compositions which flow readily either in injection or ordinary pressure molding until the mold cavity is filled and the full hydrostatic pressure is developed, and then cure rapidly as they come up to curing temperatures. The avoidance of the rubbery stage, and the ready cross polymerization at molding temperatures results in accuracy of dimensions and insert positions, and a rigid non-leathery cured part of high accuracy both as to dimensions and surface.

Since chromophore groups may be developed in the reaction of furfural and phenols, dark-colored molding compositions wherein a part or all of the color resides in the resin itself, are readily provided. This results in outstanding depth and permanency of colors especially in brown and black moldings. (*Please turn to next page*)



Ideally suited to molded applications of long, deep draw, Durite was used for this drink mixer (center) which is 15 in. by 8 in., with a 12 in. base. The lamp shade (left) is 6½ in. by 7 in. and the radio cabinet measures 9 in. by 5 in. by 4½ in. All were molded by compression

A characteristic of interest to molders is the stability and freedom from scorching (sometimes called *burning*) of the furfural-phenol resins at high molding temperatures. In order to increase the per diem output of a mold, high temperatures and shorter cures are often used, but with many thermosetting compositions this results in a high percentage of rejects due to burns. The stability of furfural-phenol resins at high temperatures enables the molder to avoid this difficulty and increase the output from a mold without producing a high percentage of rejects. Furthermore, the pieces are sufficiently rigid at these high temperatures to permit hot pulling. Where furfural-phenol resin molding compounds are used the keynote of the organization is high operating temperature and a large per diem production from the presses even with difficult molded parts.

Developments during 1939

The use of furfural-phenol resins has expanded very generally both from the standpoint of tonnage and the number of molders using the product.

One of the outstanding developments in the use of furfural-phenol resins has been in the production of rapidly molded radio cabinets due to the free flowing characteristics of the material and the other advantages mentioned previously and the assurance of a large per diem production with few defective parts.

Forms available

Liquid resin or pulverized resin, or as varnishes made therefrom.

Molding compounds utilizing various fillers.

Methods of fabrication

Compression molding is usually practiced, although the molding compounds are also used for injection and transfer molding, optimum molding temperatures being 350 to 360 deg., although temperatures as low as 330 deg. may be tolerated.

Typical applications

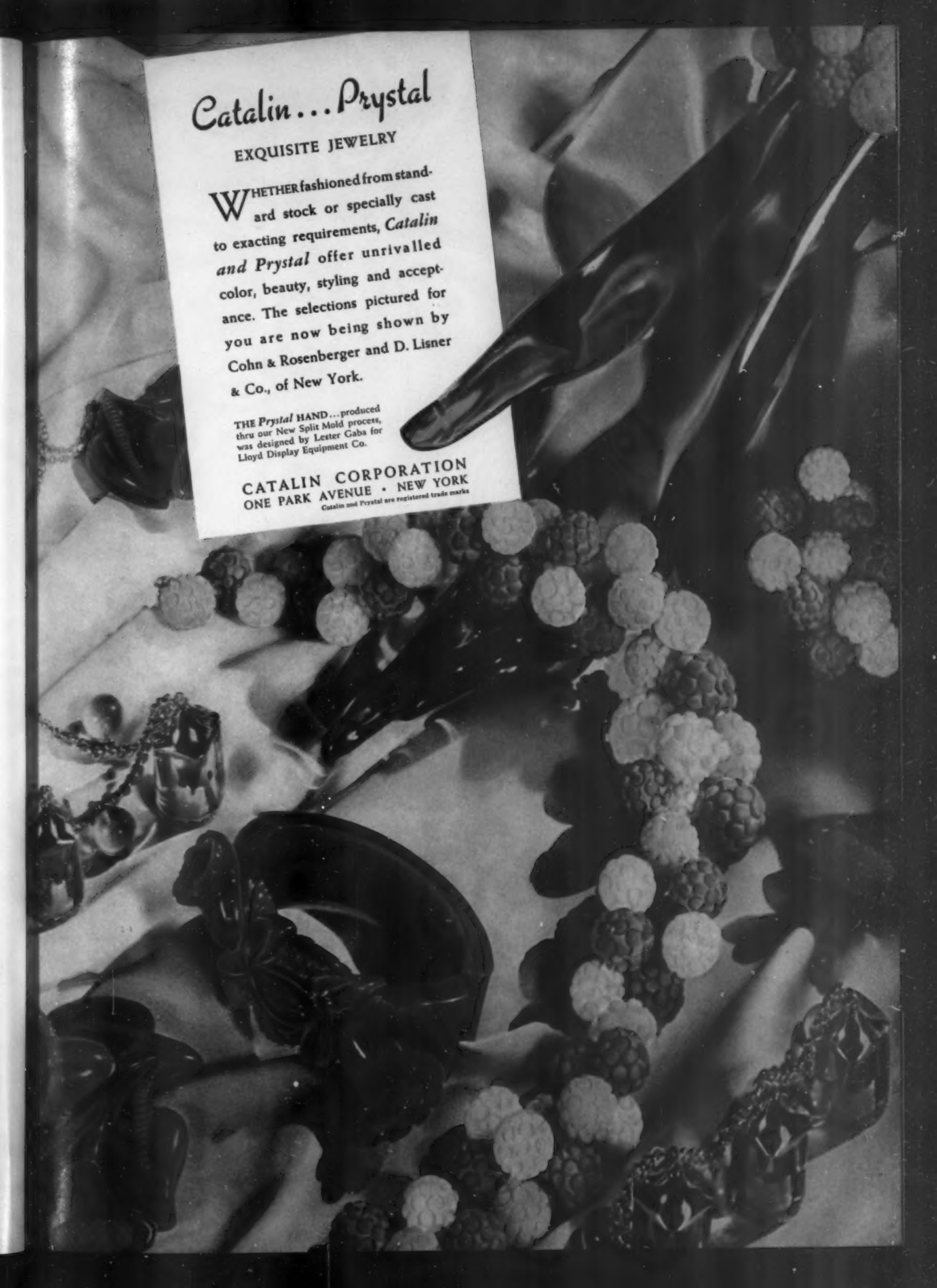
Various well-known electrical and mechanical parts, opaque, and most advantageously in a black or brown color.

Outstanding properties

Superior moldability
Stability of black and brown molded parts
Chemical inertness
Permanence of dimensions
Water resistance
Dimensional accuracy and rigidity even at top molding temperatures
Freedom from scorching or "burning" even at high mold temperatures
High heat resistance

Trade name

Durite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Catalin is Luxury--in a setting of Economy!...Economy, should you apply any of Catalin's large variety of stock forms or special castings...Economy, should you require Catalin in giant-sized draw castings...Economy, when—through Catalin's new and highly developed process of split-mold castings—you desire specially designed undercuts and curved hollows.

A review of these eight pages will acquaint you with Catalin's possibilities. To the reading thereof we supplement this invitation..."Save and Have—with Catalin". Our able staff of designers and engineers is yours to command.

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Straight Draw castings
are proving practical from
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RESIN #900

"No. 900" is a development that carries further than the exquisiteness of its new colors and new beauty.

In the brush field for which it was originally formulated, manufacturers found that it stood up under rapid fire production drilling... it was tough... it didn't crack... it gave bristles a firm supporting wall... it was unaffected by water, soap or lotion.

This industry's findings, therefore, now lead us to formally adopt Catalin No. 900 and commend it, for strength and workability, to all users of resins. Because Catalin is a cast plastic, preparatory mold costs are negligible. It encourages the projection of a variety of patterns—and makes it possible to produce them economically. It is, therefore, practical for small as well as large quantity production.

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The use of Catalin creates an incomparable beauty of form—and of color. Its effect is luxury and prestige . . . its economy—a proven factor. The rich jet black Catalin PALL MALL display you see here, is a split-mold casting—
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They're better Naturally
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26
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A far-reaching development... small *Catalin* lenses... the largest less than ½" dia. create an effect equivalent to luminous tube lighting—at a fraction of its cost—and more legible. Provides any desired color combination... gives full freedom to design. Ordinary bulb illumination from within the sealed frame is transmitted to the *Catalin* lenses—and reflected in all directions therefrom in magnified brilliance.

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LIGNIN PLASTIC

by ROBERT M. BOEHM*

WOODY MATERIALS USED IN THE MANUFACture of industrial products may be roughly classified as extractives, hemi-cellulose, cellulose and lignin. The extractives include water solubles, turpentine, rosin, tannins and similar materials, and may be ignored for the purpose of the present discussion.

Hemi-celluloses are present to roughly twenty percent of the remaining material. These are the wood sugar anhydrides, divided as hexosans and pentosans, and are convertible on acid hydrolysis to the corresponding sugars, which are water soluble. In the explosion process as described later, these are hydrolyzed and removed, leaving only the more resistant portion for manufacture of boards and plastic products.

Cellulose comprises about half of the woody substance and is the fibrous portion. Cellulose is the prime constituent of paper, and the highest quality papers consist essentially of pure cellulose. In the growing tree or plant, the cellulose is cemented together by the lignins and probably to some extent by the hemi-celluloses.

Lignin comprises about thirty percent of the woody material, and as mentioned, is the binder in the growing plant. In normal paper-making processes the lignin is removed, and in cases where the lignin is not completely removed, as in the cheaper grades of paper, the binding power is not appreciably utilized. This results in what might be termed the "paper-type bond," distinguished from the "wood-type bond" in which the lignins are activated and the bonding power utilized, resulting in a product having high strength, either dry or wet.

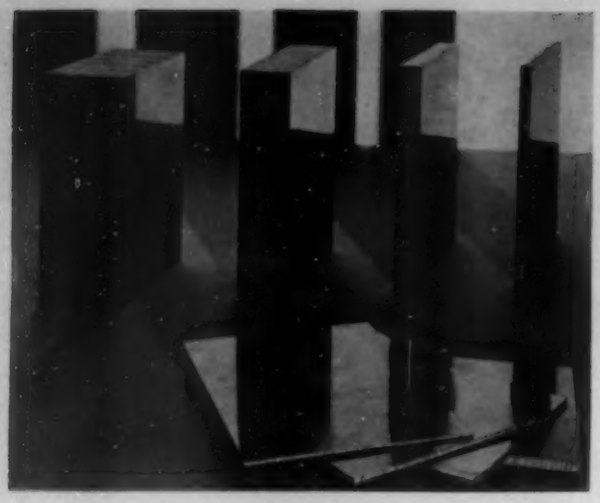
* Director of Research, Masonite Corp.

Manufacture of lignin plastic

The process is based on releasing the lignin bond in the woody material by the action of high pressure steam without removing or destroying the lignins and, in fact, so activating the lignins that their bonding power may again be utilized in the manufacture of board prod-

Composite photograph showing wood, exploded lignin plastic material, uncured (Benaloid) and cured (Benalite) lignin products

Lignin plastic may be molded or machined as these parts illustrate. (Photos, courtesy Masonite Corp.)



Commercial Benalite, the cured lignin plastic, is available on the market in flat panels only. These panels may be had in thicknesses from 1/10 in. to 1 in. The surface dimensions are limited to 4 ft. by 12 feet

ucts. The high temperature steam treatment leads essentially to an acid hydrolysis, the acids consisting of acetic and formic acids, developed from the woody material itself under the temperatures employed.

Wood chips are charged into guns each having a capacity of about twelve cubic feet and are treated with steam at pressures up to 1200 lbs. per sq. in. for a matter of seconds. Normally, the entire cycle, including filling and emptying of the guns, will be about one minute. In this time the lignins are first softened by the high temperature steam and then upon sudden release of the chips to atmospheric pressure, they are exploded by the high internal pressure, resulting in a mass of fibers and fiber bundles, all still containing their natural coating of lignin. The hemi-celluloses are largely hydrolyzed and removed, the cellulose is partially hydrated but otherwise substantially unchanged, and the lignin has been reactivated so that under suitable conditions it is available to again furnish the wood-type bond which obtained in the growing tree.

In the manufacture of the normal products, this fiber is formed into mats and pressed under pressures ranging from about 50 lbs. per sq. in. to about 300 lbs. per sq. in., depending upon the density desired and at temperatures of about 180 deg. C. until all possible moisture has been removed and the fibers are again bonded by the coating of lignin.

In the study of this pressing method, it was found that the lignin under these conditions actually undergoes a type of plasticity in some ways unlike that experienced with thermosetting resins. For example, after the fibers have been properly bonded under these conditions, the lignin has apparently become set to such an extent that the fibers cannot be disintegrated and rebonded under the same conditions.

Similarity of this action to that of the thermosetting resins naturally led to further study of this phenomenon. It was found that the various fractions of the exploded fiber exhibited somewhat different plasticities and one fraction was isolated which exhibited a very high degree of plasticity and which, when molded, produced a product similar in many ways to phenolic laminated material. Some drawbacks were found from the standpoint of both physical properties and resistance to various chemical agents, but with this as a lead, intensive research finally resulted in producing a type of heat treatment under very carefully controlled conditions of temperature and moisture content of the chips and with careful regulation of the degree of hydrolysis. This resulted in the entire mass being reduced to a plastic state, the products of which, when cured, exhibited the properties desired in a laminated plastic sheet.

Experiments on a commercial scale have been under way for two or three years. A large press has now been installed, having twelve openings and pressing panels which trim four feet by twelve feet. Pressures up to 2500 lbs. per sq. in. are available with temperatures up to 280 deg. C. The press is equipped for heating and chilling rapidly and uniformly and is extremely accurate in its construction and in the application of pressure. While the unusually high temperatures and pressures available in the press are not required for the manufacture of the standard cured product, they make possible many modifications and variations.

General characteristics

The product is normally cured at temperatures of about 175 deg. C. and pressures of about 1500 lbs. per sq. in. The only plasticizer required is about four percent of moisture which is normally present at ordinary humidities. Curing is very rapid, in fact it is only required that the temperature of the plastic material be raised to the curing temperature before chilling is started.

The resulting sheet can be surfaced with synthetic resins and colors in the customary way, or for some industrial applications it can be made without any surface material, considerably reducing the cost of the material for applications where surface resin is undesirable or is not required. It is made in all thicknesses from .100 in. to 1.00 in., and although it is suitable for making many shapes, it is normally furnished only in flat panels. It has a specific gravity of 1.45, a modulus of rupture of about 20,000 lbs. per sq. in., a tensile strength of 10,000 lbs. per sq. in., a compressive strength of about 25,000 lbs. per sq. in., a modulus of elasticity of about 2,000,000 lbs. per sq. in., and a 24 hr. water absorption of less than 1 percent. Its dielectric properties are very good, particularly its resistance to surface arcing. It may be drilled, tapped or turned readily, presenting a lustrous black finish.

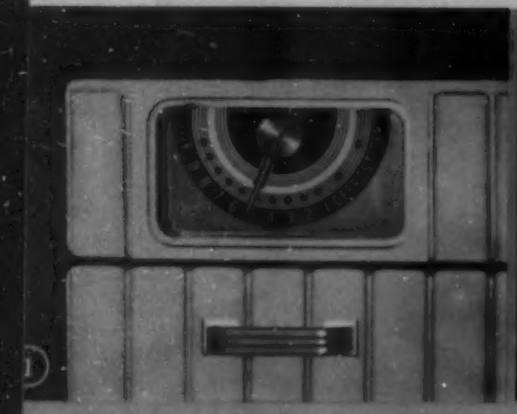
Extensive research is still being carried on, since although the present product is perfectly competitive with existing products at the present time, it is felt that some further modifications may be made which will open new fields which are not available to present laminated plastics, both from a cost and a quality standpoint.

9 Reasons why . . .

a new combination of properties, found only in "Vinylite" Plastic Sheets, is bringing new possibilities to many products . . . making them better—more lasting—more durable—lighter—more salable.

Here's how . . . . . .

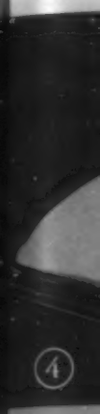
9 Reasons why "Vinylite" Plastic Sh



Philco uses "Vinylite" plastic sheets for the dial on the new Conservador refrigerator because they won't warp from water or moisture absorption. Tests show that these sheets absorb only 0.05 per cent water during immersion for 24 hr. as compared with 1.5 per cent for other plastic sheets.

Pan American Airways uses "Vinylite" plastic sheets for wainscoting in the dressing rooms of their new Clipper ships because they are light in weight, won't warp or shrink, and are non-flammable. They have a colorful and decorative value, are stainproof and easy to clean.

Formica uses "Vinylite" plastic sheets for nickel plating barrels because they are chemically inert . . . are not affected by nickel plating solutions. In addition, they are strong and tough and resist the abrasive wear which is involved while holding and rotating the parts being plated.



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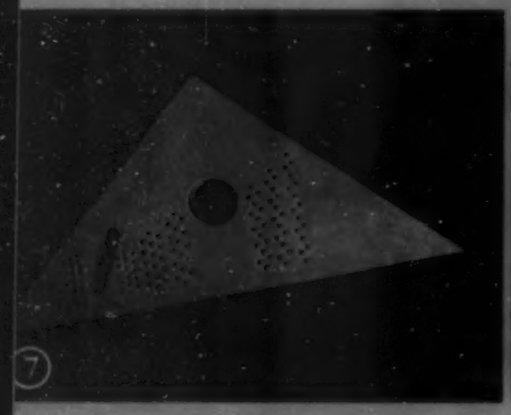
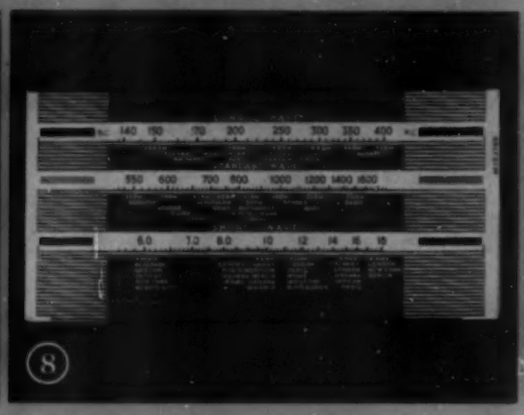
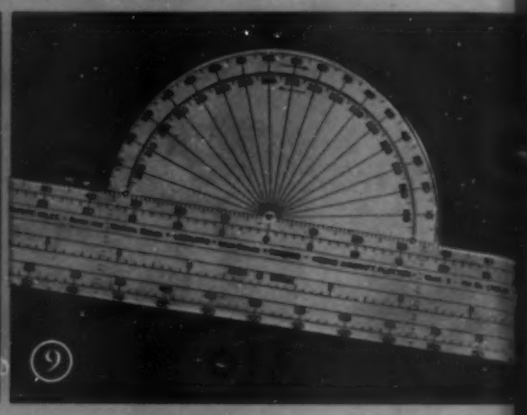


Drafting Triangles are made of "Vinylite" plastic sheets because they do not warp or shrink on aging . . . remain accurate for years. Furthermore, no seasoning period is required before putting them in use, which saves in inventory costs and seasoning equipment.



Translucent Panels are made of "Vinylite" plastic sheets for many purposes because they can be printed on in multiple colors with perfect register even when long periods intervene between press runs. They do not shrink or warp during printing or use. They are non-flammable.



Calculating Instruments are made of "Vinylite" plastic sheets because they stay accurate . . . won't curl or shrink out of shape or size. Water and moisture do not affect them. In such instruments, even the slightest inaccuracy can result in large and serious errors.

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THESE few illustrations may suggest how you, too, can use "Vinylite" resin sheets profitably. Study the unusual properties at the right and start now to put them to use in your product . . . to improve quality . . . to enhance appearance . . . to increase sales appeal.

"Vinylite" resin sheets are available in a range of thicknesses and a variety of exquisite shades and colors. They can be transparent, translucent, or opaque, and can be calendered, matte, or polished finish. Send for a book of samples and let us help you with any application you have in mind, without obligation.

Plastics Division
CARBIDE AND CARBON CHEMICALS CORPORATION
Unit of Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York, N. Y.
PRODUCERS OF SYNTHETIC ORGANIC CHEMICALS

Vinylite Resins *plastics for*

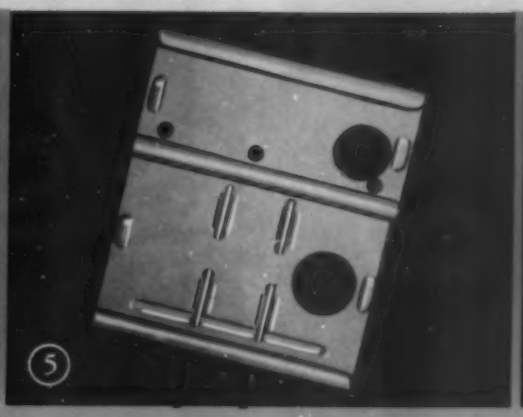
TRADE MARK

SHEETS . . FILM . . TUBES . . RODS . . EXTRUDED SHAPES . . ADHESIVES MOLD

Sheets *improve these 9 Products*

④

Hoover uses transparent "Vinylite" sheets for the window on the new Hoover electric cleaner because they don't break easily, won't soften under the heat of the lamp, are inexpensive, and are non-flammable . . . won't even support combustion. In addition, they are easy to fabricate and will not shrink and loosen.



⑤

Meat Rice Tag Holders are made of "Vinylite" plastic sheets because they won't impart any odor, taste, or toxicity to the meats. Besides, they won't warp or discolor and will maintain their shape over the wide range of temperatures and humidities encountered.

⑥

Crystals are made of "Vinylite" plastic sheets for radios, clocks, and other instruments because they can be easily deep-drawn and retain their formed shape. In addition, they won't warp or shrink and are non-flammable, which helps assure Underwriters' Laboratories, Inc. listing.

Send for Samples A request on your company letterhead will bring you, without obligation, samples of "Vinylite" resin sheets, in convenient book form. This will permit you to see and feel these unique plastic sheets in their standard colors and finishes, and will facilitate ordering by number. Every designer, fabricator, laminator, and user of plastics should have these samples. Send for yours *now*.

many purposes

Only "Vinylite" Resin Sheets Have All These Properties

1. They do not curl, blush, or get sticky—water and moisture do not affect them.
2. They are non-flammable and will not support combustion.
3. They are completely resistant to oil, grease, and alcohol, and highly resistant to practically all chemicals.
4. They are exceptionally strong, tough, and rigid even at below-freezing temperatures.
5. They are tasteless, odorless, and non-toxic.
6. They can be easily formed, drawn, and laminated under heat.
7. They do not warp or shrink on aging—no "seasoning" period is necessary.
8. They can be printed on in multiple colors with perfect register.
9. They have and maintain uniform properties in all thicknesses.

Sheets available in quantity, in a variety of colors, thicknesses, and finishes.

The word "Vinylite" is a registered trade-mark of Carbide and Carbon Chemicals Corporation.

Other Forms of "Vinylite" Resins

The plastic sheets described in the preceding pages are made of "Vinylite" resins (series V) which are also available in the following forms:

- ★ Injection Molding Powders
- ★ Compression Molding Powders
- ★ "Vinylite" Coated Paper
- ★ Calendered Film, 2 mils to 5 mils in thickness
- ★ Rods, Tubes and Special Extruded Shapes
- ★ Base Resins for Surface Coating Formulations — "Vinylite" resin solutions are supplied by leading lacquer manufacturers

"Vinylite" resins (series A) have excellent adhesive properties and are used in the preparation of both solvent and thermoplastic types of adhesives. They are also excellent binding agents for artificial wood.

"Vinylite" resins (series X) have great strength and toughness, even at low temperatures and, in highly plasticized form, are used in the newest type of laminated high-test safety glass. Unplasticized sheets are suitable for usual fabrication. "Vinylite" resins (series X) are also remarkable adhesives and leather finishing bases.

Detailed information on any of these forms of "Vinylite" resins and any of their many applications will be mailed gladly on request.

Plastics Division
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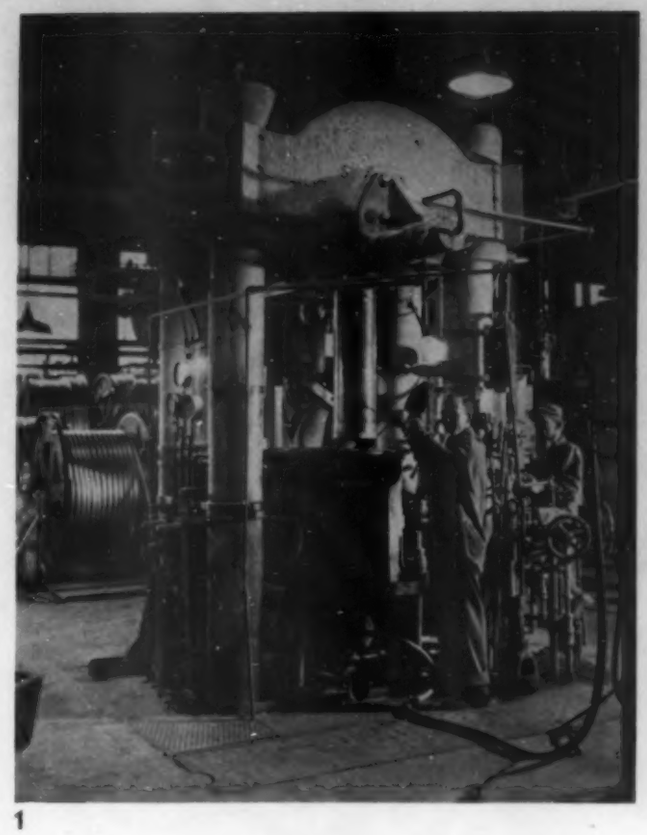
PRODUCERS OF SYNTHETIC ORGANIC CHEMICALS

The word "Vinylite" is a registered trade-mark of Carbide and Carbon Chemicals Corporation.

Vinylite Resins *plastics for many purposes*

TRADE MARK

SHEETS . . FILM . . TUBES . . RODS . . EXTRUDED SHAPES . . ADHESIVES
MOLDING POWDERS . . SURFACE COATING RESINS . . COATED PAPER



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Unvulcanized gasoline hose (Fig. 1) is covered with lead, then vulcanized on reels with steam. Oil-proof rubber insures long life to tractor tires (Fig. 2) in machine shop service. (Photos, courtesy B. F. Goodrich Company)

NEW ELASTIC MATERIALS EXPANDING THE FIELD FOR RUBBER

by W. L. SEMON*

AS A RESULT OF IMPROVED TECHNIQUE IN formulation of stocks for particular purposes, rubber is finding an ever-widening use in industry and in our everyday lives. Much of this increased utility can be attributed to the proper use of rubber-like materials or *lastics*. Seldom are these materials used alone but rather they are used in combination with each other or with rubber. Articles commonly described as being made of synthetic materials, usually are mixtures containing in addition one or more of the following: natural rubber, pigments, oils, plasticizers, resins, antioxidants, accelerators and vulcanizing agents.

A number of the rubbers, substitutes and synthetic materials available for use are shown in Table 1 (next page). General class names are given and there may be a large number of different varieties in each class. For instance in the case of natural rubber there are dozens of minor varieties available, and in the case of neoprene several lettered varieties having slightly different properties have been offered to the trade. The properties of the general materials range all the way from true rubbers to resins. Almost all are originally *thermoplastic*, some however will vulcanize by various treatments, hence are called *vulcelastics*. No effort has been made to tabulate other than the most general and characteristic properties.

The properties of finished rubber articles depend to a large extent upon the skill with which the ingredients are combined, upon the proper engineering and artistic design of the finished article, and upon careful and skillful workmanship. A vast scope of talent is utilized in the manufacture of the dainty overshoe which milady wears or in the sheer raincape which keeps off the rain. Equal skill but along different lines is utilized in the development of rubber hose for use on gasoline pumps, or for rubber-lining the mammoth tanks used in pickling steel in the new continuous sheet-steel mills.

Many of these new applications are possible only be-

* B. F. Goodrich Co.

TABLE I.—PROPERTIES OF VARIOUS LASTICS

Material	Chemical Composition	Physical Characteristics of Unvulcanized Material	Vulcanizing Characteristics	Typical Characteristics of Vulcanized Material
Natural rubber	1,4 Linear polymer of isoprene	Very rubbery. Softens at high temperature, freezes at low temperature. Pale color. Slight odor. Chemically resistant.	Vulcanizes with sulfur to become non-thermoplastic.	Very rubbery. High tensile strength, good elongation at break. Rapid recovery after stretching. Resistant to abrasion. Good electrical properties. Not affected by many chemicals or solvents. Excellent rebound elasticity
Buna S	Emulsion copolymer of butadiene and styrene	Rubbery. Does not soften much with heat.	Vulcanizes with sulfur to give very rubbery non-thermoplastic.	Very rubbery. High tensile strength and good elongation at break. Rapid recovery after stretching. Resistant to abrasion. Fairly resistant to heat. Excellent rebound elasticity.
Perbunan	Emulsion copolymer of butadiene and acrylonitrile	Rubbery. Does not soften much with heat.	Vulcanizes with sulfur to become non-thermoplastic.	Rubbery. High tensile strength, good elongation at break. Fair rebound elasticity. Resistant to abrasion. Very slightly swelled by oil. Properties not deteriorated by oil.
Neoprene	Linear polymer of chloroprene	Stiff and slightly rubbery. Softens greatly with heat.	Vulcanizes by heat to become non-thermoplastic.	Rubbery. High tensile strength, good elongation at break. Fair rebound elasticity. Very resistant to oil. Properties not deteriorated by oil. Resists corona, ozone, light.
Vistanex	Linear polymer of isobutylene	Rubbery. Softens at high temperature, does not harden at low temperatures. Colorless. Odorless. Inert chemically.	Cannot be vulcanized.	
Thiokol	Condensation product of aliphatic dihalide and soluble polysulfide	Slightly rubbery. Softens with heat.	Vulcanizes by action of heat and metallic oxides to give somewhat rubbery product still slightly plastic.	Somewhat rubbery. Fair tensile strength, fair elongation at break. Very resistant to oil and aromatic solvents. Resists corona, ozone, light.
Koroseal	Plasticized gamma polyvinyl chloride	Great range of rubbery characteristics. Plastic at high temperature. Colorless. Odorless. Resistant to chemicals and oils.	Not vulcanized.	
Gutta percha or balata	Linear polymer of isoprene; isomer of natural rubber	Tough and horny becoming rubbery at higher temperature finally melting. Good electrical properties.	Can be toughened by vulcanizing with sulfur becoming non-thermoplastic.	Tough, slightly rubbery. Good strength. High elasticity.
Thermoprene	Rubber isomerization product	Horny becoming rubbery; at higher temperature. For stiffening rubber adhering rubber to metal, or as a paint vehicle	Vulcanizes with sulfur to give a hard product like ebonite.	Hard. High strength, low elongation. Useful for stiffening rubber.
Alkyd resin	Glycerol-phthalic acid condensation product.	Oily or plastic resin.	Hardens by heat to give non-thermoplastic resin.	Strong. Tough. Chemically resistant. Good electrical properties.
Polyacrylates	Polymers of various acrylates or methacrylates.	Resinous. Softens at high temperature. Can be molded. Hard. Transparent. Chemically resistant.	Not vulcanized.	
Reclaimed rubber	Replasticized vulcanized rubber	Somewhat rubbery. Improves processing of other rubber.	Vulcanizes with sulfur to become non-thermoplastic.	Rubbery. Fair tensile strength, fair elongation at break. Most useful when used along with rubber.
Factice	Unsaturated vegetable or fish oils vulcanized with sulfur or sulfur chloride.		Already vulcanized in preparation. Non-thermoplastic.	Weak. Crumbly. Used in rubber to improve extrusion characteristics and to maintain form during cure.
Glueglis	Mixture of glue and glycerol	Dead and only slightly rubbery. Typical odor of glue. Affected by water, heat, but not by oil.	Insolubilized by chromates or formaldehyde becoming less thermoplastic.	Slightly rubbery. Used with rubber for deadening it and imparting resistance to oil.

It's PLASTICS *by* DURITE

The Stewart-Warner Corporation giant plastic table type radio featured on this page* exhibits again the adaptability of DURITE where long—free-flowing compound of great strength, moldability, and smooth, durable surface finish is required. • • This smartly designed housing by Barnes & Reinecke utilizes DURITE in combination with decalcomanias of rich burl and sliced walnut appearance. The result—a beautiful cabinet with all of the advantages of simplified production, light weight, and sales appeal. • • New portables are growing in size. For your own or other large dimension moldings the versatility of DURITE should not be overlooked. Write to Durite Plastics, the exclusive producers of phenol-furfural resins.

*Molded by General Industries, Elyria, Ohio.

DURITE PLASTICS

FRANKFORD STATION P. O. PHILADELPHIA, PA.

3

4

Neoprene household gloves (Fig. 3) resist the influence of hot soapy water, furniture polish, bleaching solutions, oils, greases, paint and antiseptics. This same material, chloroprene rubber, forms the water seal in the new steam-electric iron (Fig. 4)

cause of the synthetic *lastics* which are available. However, it is the general knowledge of the behavior of all of these materials, especially in admixture, which has made possible the rapid expansion of the field for rubber. Over one thousand different ingredients are used by rubber technicians for obtaining the desired results in one case or another. No one but a superman could know well enough the properties imparted by each of these to use them most efficiently. An extensive organization, a pooling of knowledge and a background of years of experience are behind every rubber article which is sold or used.

The value of the table can be illustrated by typical examples. A manufacturer desires a bellows to operate in lubricating oil without undue change of dimensions. His general knowledge tells him that if it were made of a simple rubber compound it would swell and disintegrate. Now he could specify that the article be made of one of the synthetics, or of glue-glycerol. The result might or might not be satisfactory. On the other hand, he could go to an experienced rubber manufacturer specializing in modern rubber compounding. He could state his problem along with the conditions to be met and could probably obtain the answer and a sample within a week.

The range of products which can be manufactured from the *lastics* staggers the imagination. Products can be made soft as chewing gum or hard as ebonite, as black as night or as delicately colored as the sunrise. Transparent articles can be made varying from sheer as silk and soft, to clear as glass and hard. Elastic articles as fragile as an art gum eraser to others as resistant to abrasion as a tire tread find their uses in industry. Articles as electrically insulating as a cable cover or as electrically conducting as an electrode are required for other services. Rubber that slides on metal like wet soap is used in water-lubricated bearings and rubber that is bonded integrally to metal is used in tank linings. Some needs require a rubber that dissolves in oil, others one that merely swells in oil, and still other uses require a rubber unaffected by or shrunk by oil. All of these conditions can be met by the skilled rubber technician working with the facilities available in leading rubber factories.

Note merely a few of the places where this knowledge has been utilized in a spectacular manner. Airplanes are fitted with elastic overshoes to break up ice that collects on the leading edge of the wing. The material used must resist water, oil, sunlight, ozone, high and low temperatures and repeated flexure at high altitudes. One certain type of hose is now being used to dispense gasoline; another to convey paint and lacquer. Even

A NEW LIGHT ON PLASTICS

When you think of plastics, think of headquarters... "the Granddaddy of them all"... and...

Get in touch with
CELLULOID

A new light on plastics... and a new angle on lamps! Bases and stands and shades of these colorful, captivating new lamps are *all* made of Lumarith!

The Franklin Lamp Mfg. Co. uses Lumarith sheet material for shades, columns, and decorations. The base is molded of Lumarith molding powder. The result is an *ensemble* of color, texture, and "feel" that assures positive sales appeal. Franklin lamps of Lumarith are offered in peach as illustrated and in other modern colors.

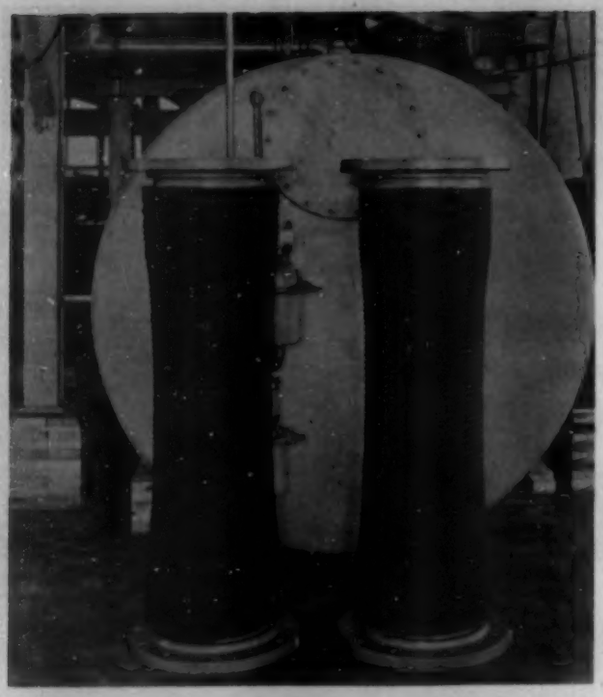
Lumarith has literally thousands of uses in making products brighter... stronger... more attractive. Production possibilities are as varied as the applications demand. Our *Molding Powder Division* and our *Sheet, Rod, and Tube Division* are set up to give you quick, expert service on all forms of Lumarith.

CELLULOID CORPORATION
10 East 40th Street, New York City
Established 1872. Sole Producer of Celluloid and Lumarith. (Trademarks Reg. U. S. Pat. Off.)

...also Headquarters for Transparent PACKAGING MATERIALS

LUMARITH

REG. U.S. PAT. OFF.



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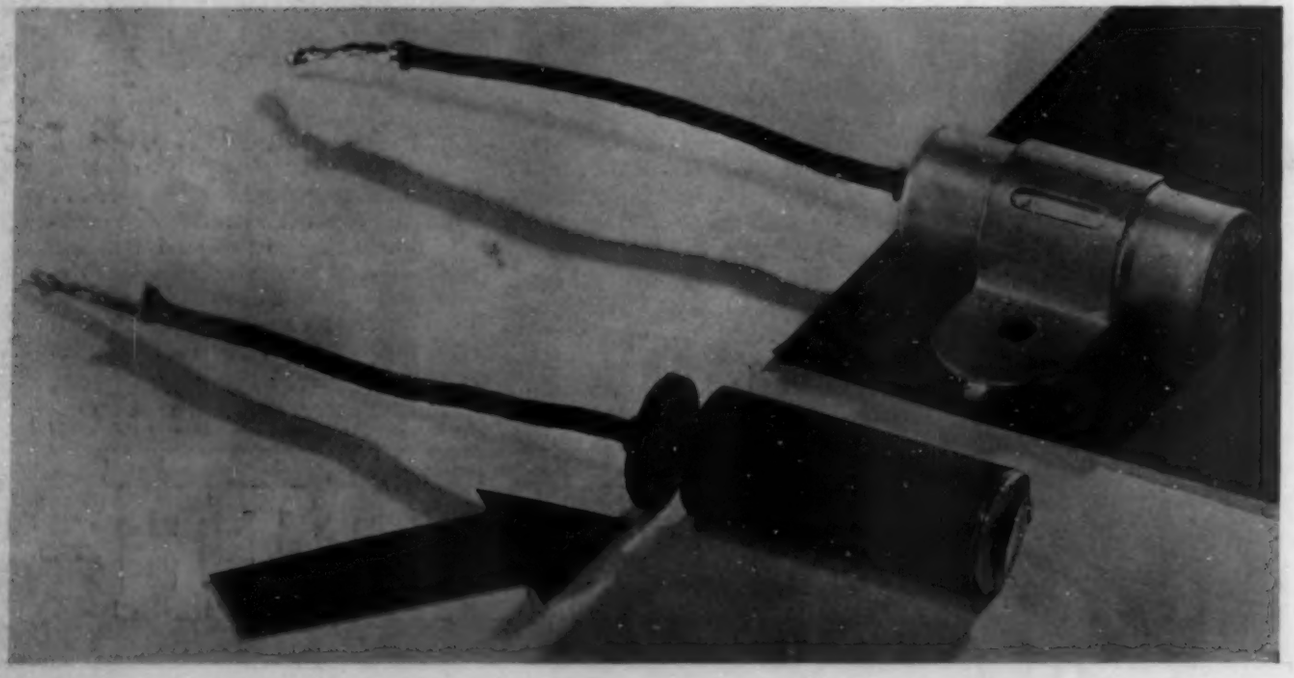
such corrosive liquids as nitric acid or sulphur chloride can be handled in flexible tubing. How different this is from conditions only a few years ago! Cars and trucks are running on oil-proof tires, and men working in oily places are wearing oil-proof soles. Oily machinery is set on elastic mountings which insulate from sound and vibration and are unaffected by oil. Autos, street cars and streamlined trains run much more smoothly when vibration and sound are absorbed by rubber made to meet very stringent and definite specifications. Cartons are printed using plates made from oil-proof rubber, and type is inked with ink-resisting rubber rolls.

Improvements in the art and science of the use of rubber are developing so rapidly that things are being done today with rubber or rubber-like products that would have been considered impossible yesterday. Many of these advances have been accomplished by the proper use of newer synthetics and have been made possible through the knowledge and experience collected in laboratories of leading rubber companies.

6

Hose and valve seats of Thiokol were used on a scale built for the Cuban government for weighing cargoes of oil and gasoline. Two lengths of hose are shown in Fig. 5. The same material is used for filler spouts (Fig. 6) on automobiles because it is impervious to the action of gasoline. Synthetic rubber washers are also used for Auto-lite condensers (Fig. 7)



7

STYRON

FOR INJECTION MOLDING

Styron* (Dow polystyrene) gives injection molding a new impetus. It is particularly suited for high-speed production and has reduced many molding cycles by 25 per cent.

Being the lightest commercial thermoplastic (Sp.Gr.1.07), more Styron moldings per pound are obtained. Its dimensional stability and low mold shrinkage (.002" per inch) permit forming molded parts with utmost accuracy. Combined in Styron, these features make possible low unit production costs with injection molding.

AS AN ELECTRICAL INSULATOR—Styron, with its power factor of .0001 to .0002, is the equivalent of fused quartz, making it suitable for use in high frequency television equipment and transmission cables.

THE CHEMICAL RESISTANCE of Styron to acids, alkalies, and alcohol enables it to serve in chemical apparatus, for bottle caps, and cosmetic containers. The A. S. T. M. 96-hour water immersion test shows no measurable absorption for Styron.

MECHANICAL PROPERTIES—Molded Styron has a tensile strength of 5500 pounds per square inch and an impact strength, retained at −70°C., of .2 foot pounds.

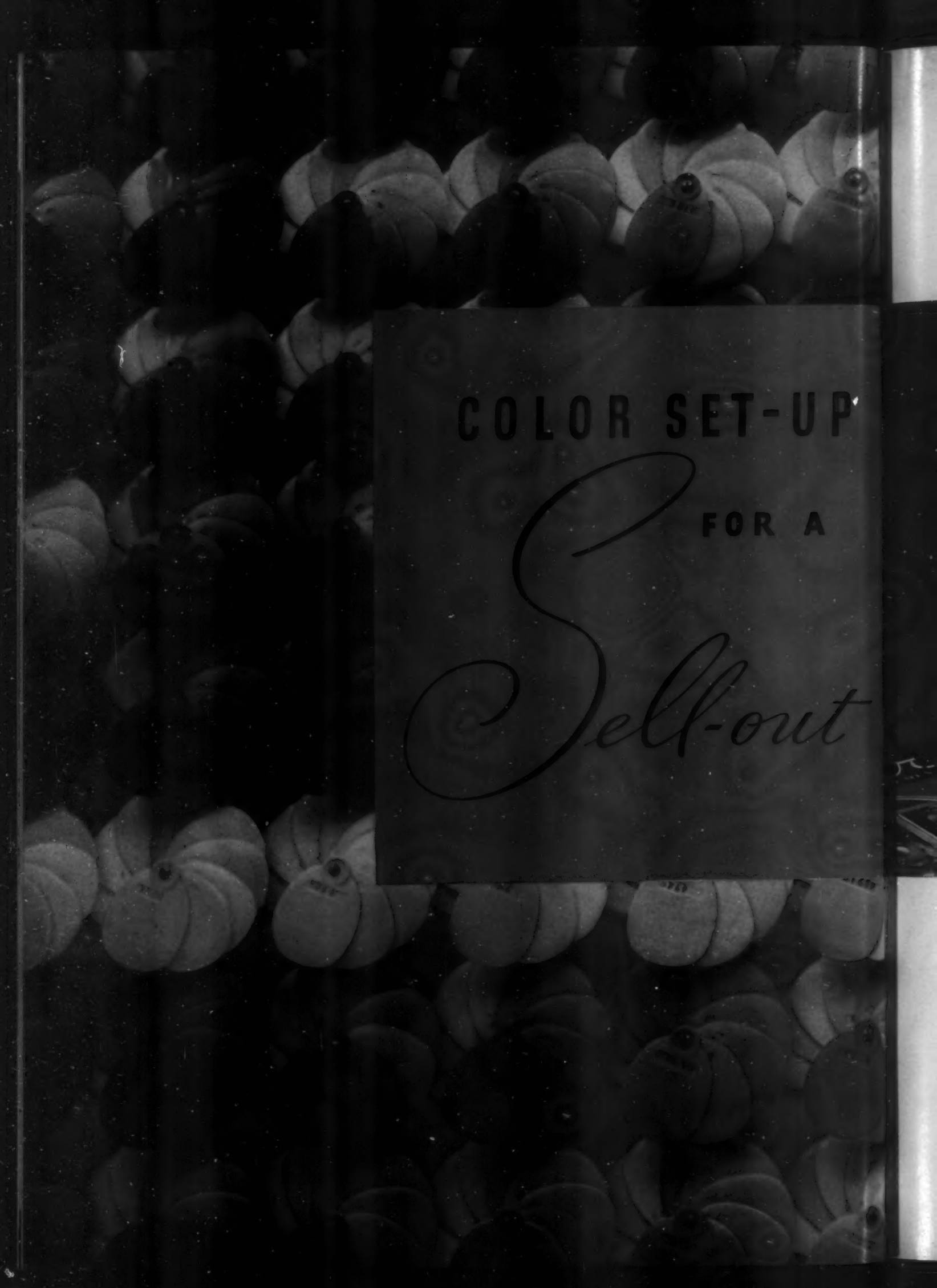
COLOR—Styron, naturally water white, is adapted to a wide variety of transparent and translucent colors.

These unique properties of Styron, along with its improved mechanical properties and low injection molding costs, give users and molders of plastic products an increasingly valuable new material.

For further information, address your inquiry to—

THE DOW CHEMICAL COMPANY
1810 EAST MAIN STREET MIDLAND, MICHIGAN
Branch Sales Offices: 30 Rockefeller Plaza, New York City; Second and Madison Streets, St. Louis; Field Building, Chicago; 9 Main Street, San Francisco; 4151 Bandini Blvd., Los Angeles.

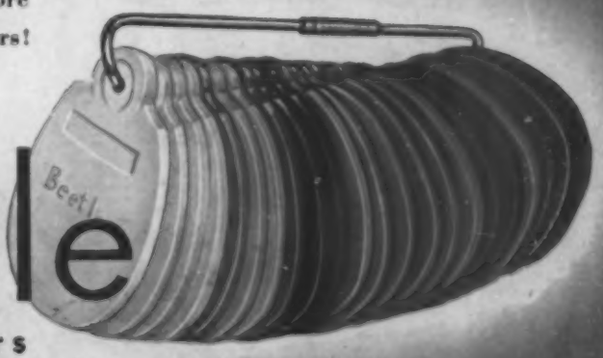
*Trade Mark Reg. U. S. Pat. Off.


COLOR SET-UP
FOR A
Sell-out

THERE is a display of sales dynamite on the opposite page—colors with tremendous selling power ... colors that can give "sales-oomph" to any product, whether a package, a housing, or a part. And here is an outstanding example of how color can be put to use. Emerson Radio knows from experience that Beetle* color sells radios and cuts production costs through fast, economical molding, simplified assembly, and elimination of finishing steps. For Beetle is all color and the molding of a Beetle

housing is one simple operation. The Beetle Emerson selected for this smartly designed model is new and interesting—a rich cream-onyx that suggests polished marble ... *It is a color set-up for a sell-out!*

There are hundreds of Beetle shades and tints. We will be glad to help you make a choice for your products. Write today for more information on this great show—Beetle ... all color and in all colors!



BEETLE PRODUCTS DIVISION OF
AMERICAN CYANAMID COMPANY

30 ROCKEFELLER PLAZA, NEW YORK, N.Y.

*Trade-mark of American Cyanamid Company applied to urea products manufactured by it.

Beetle

it's all color and in all colors

WHY

CLAREMONT

means "COTTON FLOCKS"
To Leading Molders

- Over 20,000,000 lbs. of first quality cotton flocks have been produced by CLAREMONT for the plastics industry.
- CLAREMONT flocks are famous for their longer fibre lengths, uniformity of bulk and freedom from particles.
- For twenty-one years, CLAREMONT has supplied practically every known leading plastics molder.
- Costs are "right" because CLAREMONT has built its own special machines—not on the market—for extra high speed production.
- CLAREMONT can make quick deliveries of any grade and quantity to any point in the United States and abroad.

CLAREMONT WASTE MFG. CO.

Claremont New Hampshire

THE COUNTRY'S LEADING MAKERS

PARACOUMARONE-INDENE RESIN

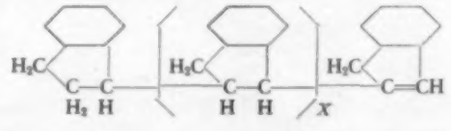
by J. A. KENNEY*

JUST ONE HUNDRED YEARS AGO, E. SIMON SUCceeded in polymerizing styrene to form a resinous body. He, no doubt, would have been justly proud of his achievement could he have foreseen what an important part the principle of polymerization would play in the development of the resin industry today.

Paracoumarone-indene resins are produced through polymerization and are among the first synthetic resins developed commercially in the United States. This class of synthetic resin had its beginning in the work of Kraemer and Spilker, who in 1890 isolated coumarone and indene from certain coal-tar light-oil fractions and polymerized them by sulphuric acid to form resins. This work bore fruit when further study of practical manufacturing methods resulted in the establishment in the United States during the World War of a commercial process for producing paracoumarone-indene resins.

Chemistry of their production

Among the coal-tar light oils recovered from by-product coking operations is that fraction distilling between 150 to 200 deg C. It is rich in indene, coumarone and homologous bodies including their methyl derivatives. The naphthas after suitable refining operations are treated by intimate admixture with small quantities of concentrated sulphuric acid to effect polymerization of the reactable constituents. The acid is settled and removed, any residue remaining is neutralized and the resinous components separated by distilling off the unreacted naphthas. The resin remains in the still. The parent materials indene and coumarone may be represented by the structural formulas shown above. The polymerization is assumed to be a chain reaction of the following general pattern:



By regulating carefully the conditions of the reaction it is possible to produce a series of resins varying from semi-fluid viscous resins, to plastic and hard brittle grades and in color from dark brown to pale straw.

General characteristics

No property, probably, is of greater importance to the technician in the development of plastics, adhesives or coatings than that of the ready compatibility of paracoumarone-indene resin with a wide variety of resins, polymerized bodies and plasticizers. In general, the various grades of this resin are relatively low in molecular weight (the hardest has an average value near 1000) and at temperatures above their melting points are completely fluid. These characteristics enable them to be utilized readily in modifying the properties of many other resinous bodies and compounds based on them.

In one industry alone several million pounds of paracoumarone-indene resin per year are used because it readily blends with and supplements the properties of certain bitumens. However, a more vivid realization of the possibilities in various fields is gained through a survey of the many resins, waxes and bitumens which, under proper conditions, can be blended with paracoumarone-indene resin (Table I). The wide range of solubility includes the coal-tar solvents, many petroleum thinners, esters, ketones, chlorinated hydrocarbons and cyclic alcohols and many vegetable oils.

The use of this resin in rubber compounding is one of the best illustrations of the adaptability of this material for a wide variety of uses. The hard grades have functioned, for example, as softeners to facilitate milling and compounding operations making smoother mixes with less expenditure of mechanical energy. In addition, they have been used to improve flowing and extruding properties of the compound. In various finished rubber compounds the individual grades perform different functions. The hard grades impart a gloss to soft and hard rubber products and in sufficient quantity stiffen the compound. The soft grades are used in many soft rubber products including sponge and compounds of a low modulus of elasticity. To improve the adhesive strength and tack of rubber adhesives of both the solvent and latex type the hard and soft grades of the coumarone-indene polymers have found wide application. Proportions of 10 to 100 percent of resin based on the rubber have been used.

Recent developments

The great benefits accruing to the automotive, electrical and similar industries through the rapid commercial development of polychloroprene, polymerized butadiene and related rubber-like products have not been overestimated. Compounders working with these products have come to realize the value of paracoumarone-indene resins as plasticizing agents and tackifiers of high efficiency.

In homes, hospitals, public and industrial buildings mastic floor tiling, much of which has been made with paracoumarone-indene resin binder, has found increasing use over the past ten years. Mastic floor tile is suited for many locations not only because it is available in many attractive shades and marbleized effects

* The Barrett Co.

TABLE I. LIST OF PLASTICS COMPATIBLE WITH COUMARONE-INDENE RESINS

Waxes	Natural Resins and Derivatives	Synthetic Resins	Rubber	Bitumens
Beeswax	Batu	Alkyd (2)	Balata	Asphalt
Candellila	Congo (run)	Chlorinated diphenyl	Chlorinated rubber	Coal-tar pitch
Carnauba (1)	Rosin	Methacrylates	Chloroprene	Fatty acid pitch
Ceresin	Congo ester	Modified phenolic	Factice	Gilsonite
Halowax	Dammar	Oil soluble phenolic	Gutta Siac	Pine tar
Japan	East India	Petroleum resins	Jelutong	Vegetable pitch
Lanolin	Elemi	Polystyrene	Polysulphide	
Opal	Ester Gum	Vinyl (3)	Resinified rubber	
Spermaceti	Limed Rosin		Rubber	
Stearic acid	Lead Resinate			
	Zinc Resinate			

(1) (3) A small proportion of paracoumarone-indene resin (depending on the grade) may be blended with these materials.

(2) Long oil or rosin modified alkyd resins blend with the coumarone-indene polymers.

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but because such floors are quickly laid and easy to maintain. The average yearly output of mastic floor tile has grown to approximately 50,000,000 square feet.

The process for the manufacture of mastic floor tile is relatively simple. To produce tile-base paracoumarone-indene resin is plasticized with various selected pitches or specially processed oils so that a binder satisfactory in physical properties and light in color is obtained. The binder and mineral fillers, including those of the fibrous type, with a smaller amount of granular material and pigment are thoroughly blended in mixing rolls or other standard type masticating equipment. A suitably prepared binder provides a mix which at temperatures above the melting point of this binder flows together smoothly. Thorough wetting of the filler due to fluidity of the binder at mixing temperature provides a dense plastic with good coherence. The plastic is sheeted through rolls, polished and cut into standard sizes.

Transcription records, so necessary to the radio industry, have been prepared from vinyl resins, including such types as polyvinyl acetals. The utility of paracoumarone-indene resin is well demonstrated in its use as a flux with some of the vinyl resins to improve the milling and flowing qualities and to increase the fidelity of the plastic in reproducing the fine contours of the master mold. The records so produced are light in weight and have a minimum of surface noise.

So many possibilities exist for laminated products in industrial uses that an illustration of the use of paracoumarone-indene resin in supplementing the properties of certain phenolic resins is worthwhile considering. Sheets of paper or paper board are saturated with paracoumarone-indene resin from solvent solution. After drying the sheet is passed through a solution of oil-soluble phenolic resin. Two or more sheets so treated are laminated by heat and pressure. Thus the more expensive phenolic resin is partly replaced by the thermoplastic resin which blends with and forms a strong bond with the phenolic binder.

Coumarone-indene polymers have been introduced as beater sizes for fibrous materials and lamination of such sheets has been effected by means of heat and pressure.

It can be seen that many other undeveloped uses for paracoumarone-indene resin are possible since this resin blends in certain proportion with many of the plastics developed within the last few years. Its compatibility with polystyrene, chlorinated rubber, benzyl cellulose, ethylcellulose, some acrylic ester polymers and other products of this type indicate new avenues for development in the extending fields of usefulness for blends of the paracoumarone-indene resin.

Forms available

Viscous liquids to high-melting solids
Color ranges from pale-yellow to dark red-brown or almost black

Typical applications

Mastic floor tile
Rubber compounding
Protective coatings
Transcription records
Paper impregnation

Outstanding properties

Acid, alcohol, alkali, brine and water resistance
High electrical breakdown
Low power factor (60 cycles at 80° C.–0.5–1.0% and at 2500 kilocycles at 21° C.–0.04%
Neutral reaction
Thermoplasticity
Non-saponifiability
Specific gravity of 1.08–1.14
Low viscosity in solution
Wide range of solubility

Trade names

Cumar, Nevindene

SINCE 1927

MASURON

MOLDING COMPOUNDS

Slabs — Granulations

Extrusion Pastes

Rich colors . . . depth . . . pleasing mottled effects . . . and lustrous finish . . . characterize MASURON molding compounds.

In a wide variety of grades, MASURON is readily available for every plastic need.

MASURON Injection Molding Powders are uniform and quick-setting and assure moldings of the highest quality and strength.

Phone or write for samples and technical suggestions.

JOHN W. MASURY and SON

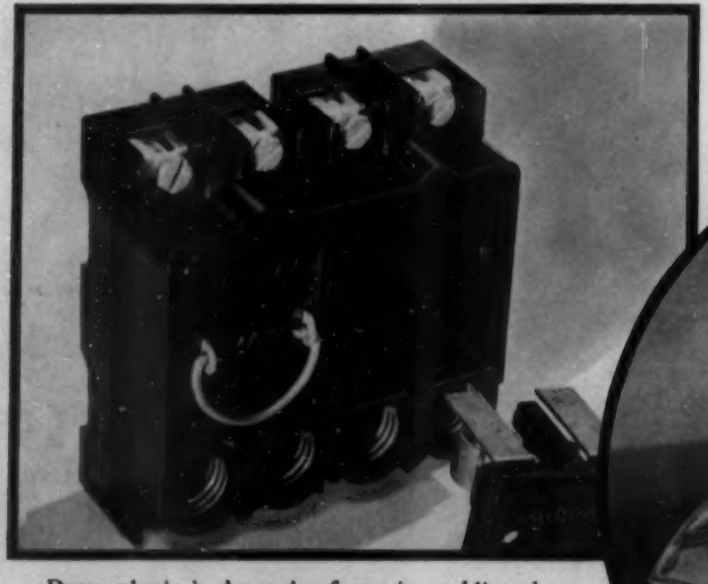
Masuron Division

48 JAY STREET BROOKLYN, N. Y.

HAVE IT YOUR

The new, portable desk-type Cardineer file is based on the same principle as the large, cabinet type unit, and has a 6¼-inch diameter wheel of brown mottle Durez plastic. As in the larger model, Durez saves weight, simplifies production.

Durez has long been a leader in the cosmetic field. Hence its use in the well-known Kitstick where its lustrous beauty combines and contrasts with gold to form a striking handbag accessory.



Durez plastic is the major factor in enabling the manufacturer of the Murray Combination Main and Range Switch to obtain a reduction of 7 lbs. per switch in shipping weight. Durez also gives excellent dielectric strength and self-insulating qualities.

Many Durez compounds are specially heat resistant, which makes them particularly suitable for such molded articles as iron handles, like this one which graces the new Never-Lift Iron.

OWN WAY!...

Do YOU want to give your product more beauty, lighter weight, greater sales appeal? Do you want to simplify its production... sell it at a better price? Then you ought to know how Durez can help you.

These phenolic plastics have so many advantages over heavier, bulkier materials... are so readily adaptable to countless products and processes that you can "have it your own way" when it comes to design and application.

In addition to these inherent advantages Durez gives you a choice of more than 300 molding compounds, and a host of special bonding, impregnating and coating resins. From these you are almost sure to find one or more that will have exactly the properties your product needs. Our technical staff will gladly work with you, just as they have with hundreds of other manufacturers for years. Write Durez Plastics & Chemicals, Inc., 710 Walck Road, North Tonawanda, New York.

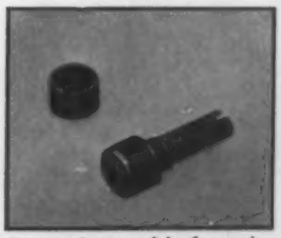
All the latest models in the Montgomery Ward line of electric washers are equipped with six Durez plastic parts for good looks and resistance to soap or chemicals in washing solutions.

The use of Durez plastic is an old story in the radio cabinet field—where something new is always happening! The cabinet of this new Zenith model is a Durez plastic molding of outstanding attractiveness.

Send for latest issue of Durez Plastics News... packed full of useful information on newest developments in the plastics field.

SPECIAL COMPOUNDS FOR SPECIAL PROBLEMS...

Durez 114 SB is a special molding compound highly recommended for parts, such as these switch housings, that must be machined or sanded.

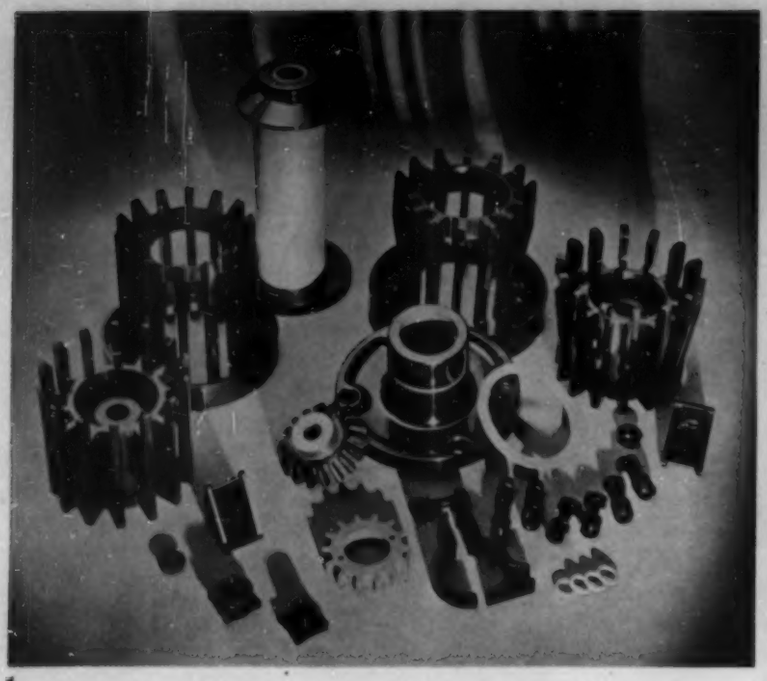


Are you interested in fast-curing materials? Durez has recently developed a compound which is one of the fastest curing plastics on the market!

Typical of the wide range of special Durez compounds is Durez 2270—a plastic developed particularly for molding around large inserts, where strength plus elasticity is a "must."

DUREZ PLASTICS & CHEMICALS, INC.

PLASTICS THAT FIT THE JOB



1

2

Molded and laminated jet unions, thread guide holders, brackets, seal rings, washers, etc. (Fig. 1) made for International Rayon Corp.'s new rayon working machinery. Fig. 2 illustrates a 21-in. wheel, molded in two halves—each half weighing 7½ lbs.—used on the Cardineer filing system. All these items were made with Durez phenolic resins

PHENOLIC RESINS (MOLDING TYPE)

by H. S. SPENCER and A. F. SHEPARD*

PHENOLIC RESINS ARE OBTAINED BY THE reaction of almost any phenolic body (such as phenol, cresol, resorcinol, naphthol) with almost any carbonyl compound (such as formaldehyde, acetone, benzaldehyde, furfural—or their reaction products with ammonia) in the presence of almost any catalyst (hydrochloric acid, lime, ammonia). The fundamental reaction was discovered by Baeyer in 1872; its possibilities were realized by Story, de Laire and others in the period 1900–1905, and finally commercially exploited by Baekeland, Redman and Aylsworth around 1909. Because of the wide scope of the reaction, phenolic resins may be obtained with a wider range of useful properties perhaps than any other resin. From a practical standpoint the phenol most generally useful is phenol itself and the most useful aldehyde is formaldehyde, although the development of special properties often requires other raw materials.

Chemistry of the reaction

The product obtained from the reaction of phenol and formaldehyde depends primarily upon the following factors:

1. *Relative amounts of phenol and formaldehyde.* When the molecular ratio of phenol to formaldehyde is greater than 1:1, the ultimate products are fusible (or thermoplastic) resins or even simple crystalline compounds. The simplest ultimate product of the reaction forms as follows:

$$2C_6H_5OH + CH_2O \longrightarrow HO_{c6}H_4—CH_2—C_6H_4OH$$

When the molecular ratio of phenol to formaldehyde is somewhat less than 1:1, the ultimate reaction product is a cured (set) resin. Such a resin may be regarded as made up of very large, complicated, three-dimensional molecules in which phenol nuclei are probably linked together with methylene groups.

2. *Nature of catalyst used.* With strongly acid catalysts the reaction tends to go at once to the ultimate product. Consequently, acid catalysts are normally used in the production of "two-step" resins where only a limited amount of aldehyde is combined with the phenol to give a thermoplastic resin which is later mixed with more aldehyde or hexa.

With alkaline catalysts intermediate products are formed which are capable of further reaction, e. g.:

* Durez Plastics and Chemicals, Inc.

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IMPROVE YOUR RESINS BY USING "NATIONAL ANILINE"

TOXILIC (MALEIC) ANHYDRIDE—A uniform, white, chemically pure product of increasing importance as a raw material to producers of *quality resins and plasticizers.*

CHEMICAL SPECIFICATIONS

MOLECULAR WEIGHT	98
DENSITY	1.42 at 28° C
MELTING POINT	52.6° C
BOILING POINT	202° C

SOLUBILITY — Readily soluble in benzene, hydro-carbons, acetone, ethyl ether and chloroform.

PHTHALIC ANHYDRIDE—A standardized, pure white, flake product from production sources adequate to meet your every demand

OTHER RELATED CHEMICALS—In addition, the following chemicals are now available in commercial quantities: Succinic Acid and Anhydride • Malic Acid • Fumaric Acid • Toxilic (Maleic) Acid.

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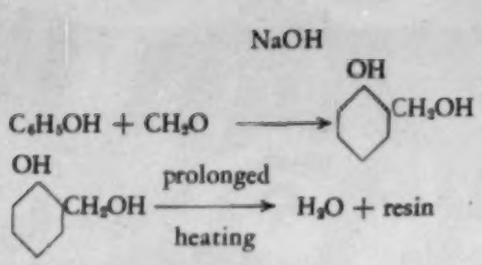
BOSTON	150 Causeway St.	GREENSBORO	Jefferson Standard Bldg.
PROVIDENCE	15 Westminster St.	ATLANTA	140 Peachtree St.
CHICAGO	357 W. Erie St.	NEW ORLEANS	Masonic Temple Bldg.
PHILADELPHIA	200-204 S. Front St.	CHATTANOOGA	James Bldg.
SAN FRANCISCO	517 Howard St.	PORTLAND, ORE	646 N. Thompson St.
CHARLOTTE	201-203 W. First St.	TORONTO	137-145 Wellington St., W.

BRANCHES AND DISTRIBUTORS THROUGHOUT THE WORLD



With such catalysts as ammonia or amines the reaction product may contain some of the catalyst in chemical combination.

3. *Time and temperature of reaction.* Regardless of the type of catalyst used, the intermediate reaction products are convertible to the final products if heated hot enough or long enough.

General characteristics

Thermosetting phenolic resins have the widest utility. The rate of cure or set can be varied to meet almost any industrial requirement. Cured phenolic resins develop great strength and hardness and are resistant to heat, water, organic solvents, acids and mild alkalies. Electrical properties are good enough for all ordinary applications except where maximum possible resistance to surface tracking or exposure to ultra high frequency are involved. The only important property in which phenolics suffer by contrast with other thermosetting resins is their lack of color stability. Certain types may be made water white, but even these discolor in time, a change which has no especial effect upon other properties. Cured phenolics are rather hard and brittle, although modified types of greater softness and flexibility can be prepared. The compatibility of cured phenolics with other resins and plasticizers is rather limited. Certain phenolics are compatible, however, with rubber, shellac, drying oils and waxes. Cured phenolic resins may be made substantially odorless.

Phenolic resins have a greater coefficient of thermal expansion then metals. They will shrink around metal inserts after molding and hold them tightly. Actual adhesion to metal is slight, resulting in easy removal from the metal mold.

Uncured thermosetting phenolics are available in solid and liquid forms, as solutions in organic solvents and in water, and in the form of colloidal dispersions.

Thermoplastic phenolics have less utility than thermosetting types. Their chief points of difference are in their extremely wide solubility in organic solvents, compatibility with other resins, and relatively poor mechanical strength. In oleoresinous varnishes and in lacquers they impart remarkable durability and weather resistance, coupled with good gloss and fast dry. Good color stability and fair adhesion can be obtained in such compositions.

Developments in 1939

While no particularly new material in this group has been developed, it might be said that the materials in their entirety have been improved. In fact, it has been the record of chemists in this phase of the plastics industry that the materials have been constantly improved year after year.

Phenolic molding compounds cure or flow faster, increasing production. Closure material made for bottle

Fink-Roselieve Co.'s cut-film-pack developing tank (Fig. 3) consists of seven close-fitting parts molded from chemical-resistant Bakelite by Boonton Molding Co. International Salt Co.'s tablet dispenser (Fig. 4) is molded of Resinox by Consolidated Molded Products Corporation

3

4

UNIQUE DESIGN in an electric fan with base, standard and housing of colorful Bakelite Molded.

SALES-SPARKLE for staple merchandise. Belt-and-buckle set with rich gift package of Bakelite Molded.

UNIFORM PRECISION in "candid" cameras is obtained by forming housings from durable Bakelite Molded.

NON-CORRODING strength and beauty. Lightweight salt water fishing reel of Bakelite Molded.

COST-ECONOMY Handsome Bakelite Molded case permits popular pricing of this fine clock.

COLOR-STYLING for tea-kettle through use of bright red Bakelite Molded knob and handle.

BAKELITE PLASTICS can help you give it colorful beauty, enduring strength, better performance, and other striking advantages that assure quick sales success

PREPARE your new-born product for the competitive battle! Give it beauty . . . lustrous color . . . enduring strength . . . compact, pleasing design . . . and production economies that foster enticing prices. Learn from these four current case histories how other manufacturers are conquering competition with Bakelite plastics:

1. Rex Venetian Blinds of translucent Bakelite Laminated created a luxurious new treatment for windows. They found immediate success at prices permitting wider profit margin . . . gave the manufacturer an important advantage over competition.
2. Speaking of its Bakelite Molded desk lamp, Polaroid Corporation says: "It would have been difficult to produce the Polaroid Desk Lamp in anything like its present form and to sell for its present moderate price if we had made it from conventional material."
3. "Bakelite plastics are largely responsible for the national sales success of Tecklite Safety Plate Switches," reports Tecklite Mfg. Co. "They have given us beauty, durability and economy, and have supplied certain factors impossible to find in other materials."
4. In creating a new model of the Wappler Cautery Scalpel, American Cystoscope Makers, Inc., obtained revolutionary advantages from Bakelite Molded. New compact design was made possible at greatly reduced manufacturing cost. The lowered sales price broadened its market. Sales jumped 1400% in 12 months.

If you have a product about to be born, or one that needs rejuvenation . . . investigate the sales-stimulating effects of Bakelite plastics. Turn the page and see what other manufacturers have accomplished with these materials. And write today for detailed booklets described on page 4 of this insert.

BAKELITE CORPORATION, 247 PARK AVENUE, NEW YORK

COLORFUL EFFECTS

like these are only one of

MANY SALES ASSETS

NOW AVAILABLE TO YOU THROUGH MORE THAN 2000 BAKELITE PLASTIC MATERIALS

In addition to their rich eye-appeal, Bakelite materials offer striking opportunities to improve the performance and production of your products. You may select molding materials, laminated stock, cast resinoids, cements, coatings and other materials possessing valuable special properties such as impact strength, transparency, high dielectric strength, or resistance to heat, moisture or chemicals. Here are some of the many types of Bakelite plastics now available:

BAKELITE *Phenolic* MOLDING MATERIALS

Rich opaque colors, plus durability to withstand daily use. This moderately-priced manicure set container is made from Phenolic Bakelite Molded.

Transparency, heat-resistance and dimensional stability. Distinctive electric shaver housed in Bakelite Transparent Phenolic molding material.

BAKELITE *Urea* MOLDING MATERIALS

Opaque and translucent effects with no sacrifice in durability. This radio cabinet is molded from Bakelite Urea material.

Highly permanent color. The delicate ivory shade of this Bakelite Urea cigarette case is unaffected by constant handling or exposure to light.

ADD STYLE, IMPROVED DESIGN, ECONOMY W

BAKELITE *Cellulose-Acetate* MOLDING MATERIALS

Toughness, combined with gem-like color and high lustre. This smart dresser set formed from Bakelite Cellulose-Acetate material, though light in weight, will withstand years of service.

Colors that rival the rainbow. These dainty wedding-ring boxes are made from Bakelite Cellulose-Acetate.

BAKELITE *Polystyrene* MOLDING MATERIALS

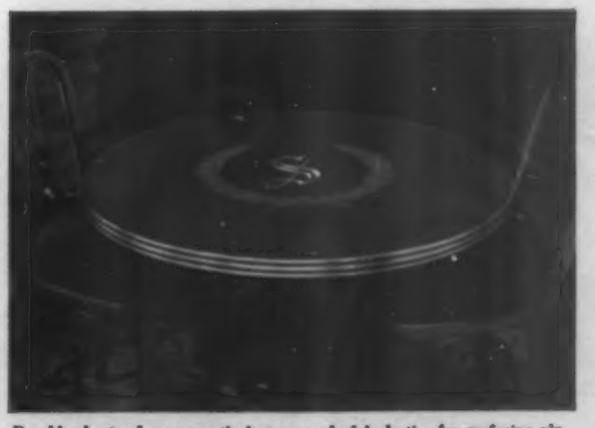
Water resistance, combined with rich, surface finish and delicate coloring. Cup, tray and stopper of this carafe made from Bakelite Polystyrene material, withstand water and other liquids.

Transparent, translucent or opaque colors that withstand moisture and chemicals. These liquor pourers are made from Bakelite Polystyrene.

BAKELITE *Cast Resinoids*

Colorful materials that may be carved or finished with ordinary tools. These varied articles are made from Bakelite Cast resinoid.

BAKELITE *Laminated*



Durable sheets of permanently lustrous, colorful plastics for surfacing plywood or other materials. Inlaid table top of Bakelite Laminated.

OBTAIN NEW INSPIRATION *for successful* DESIGNS

FROM THESE ILLUSTRATED BOOKLETS DESCRIBING VARIOUS BAKELITE PLASTICS AND THEIR USES

Bakelite Molded

A 48-page illustrated reference booklet describing many types of Bakelite phenolic molding materials, with A.S.T.M. data. Accompanying technical bulletins offer data on Bakelite urea, cellulose-acetate and polystyrene molding materials.

Bakelite Laminated

New 48-page illustrated reference booklet describing the various types of sheet, tube, rod and special-order shapes obtainable, and their broad range of uses. Contains A.S.T.M. data.

Bakelite Cast Resinoids

A comprehensive bulletin describing cast resinoids, their availability and uses, and the most efficient methods of fabricating them into various finished products.

Bakelite Resins for Paints and Varnishes

24-page illustrated booklet describing the fortifying effect of oil-soluble Bakelite resins upon modern paints and varnishes for many protective purposes.

Bakelite Heat-Hardenable Varnish, Enamel, Lacquer, Cement

40-page illustrated booklet describing heat-reactive resinoid coating and bonding materials, their properties, uses and advantages.

High Speed Abrasive Wheels

24-page illustrated booklet presenting the important production advantages of high-speed abrasive wheels bonded with Bakelite resinoids.

BAKELITE

PLASTICS HEADQUARTERS

BAKELITE CORPORATION
247 Park Avenue,
New York, N. Y.

Please send copy of the booklet checked below, to:

- ☐ Bakelite Molded
- ☐ Bakelite Laminated
- ☐ Bakelite Cast Resinoids
- ☐ Bakelite Resins for Paints and Varnishes
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- ☐ High Speed Abrasive Wheels

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Complicated electric iron handles molded of heat-resistant Makalot by T. F. Butterfield, Inc., are shown in Fig. 5. Heat resisting properties are incorporated in phenolic compounds through the use of proper fillers and careful compounding. The 22-in. blade on the electric fan (Fig. 6) is molded of Textolite by General Electric Co. for Fresh'nd Aire Corporation

caps, for example, now cures in 30 seconds and even less. Furthermore, these materials now have a greater flexibility than previous ones. Automatically stripped from the mold while hot, they are not so easily distorted in shape, but seem to have a degree of elasticity which returns them to mold form immediately upon removal. While this flexibility does not hold for very large pieces, it is a forward step and has proved advantageous to the molder. In addition, torque strength of these materials has been stepped-up considerably. Those materials with high impact strength and resistance to moisture have likewise been improved in speed of cure. Speed of cure is important to fabricators of these materials in that greater production is secured with the same equipment.

Electrical properties of the materials have generally been improved. Dielectric strength and high temperature resistance have been increased. The practice of preheating, so rapidly becoming universal, has been one major factor in the improvement of these properties.

The demand for phenolic compounds requiring special types of resins for cosmetic and liquor closures has steadily grown. The odorless, non-bleeding properties required for this type of product have been tremendously improved. The odor properties of these materials depend primarily on the resin used. The ammonia or phenol odor of the older types has been substantially eliminated. The dyestuff manufacturers have cooperated in developing brilliant colors which are non-bleeding.

Resins which form the base of phenolic molding compounds have been changed, with the result that there is greater light-fastness in many of the heretofore difficult colors to obtain in phenolics.

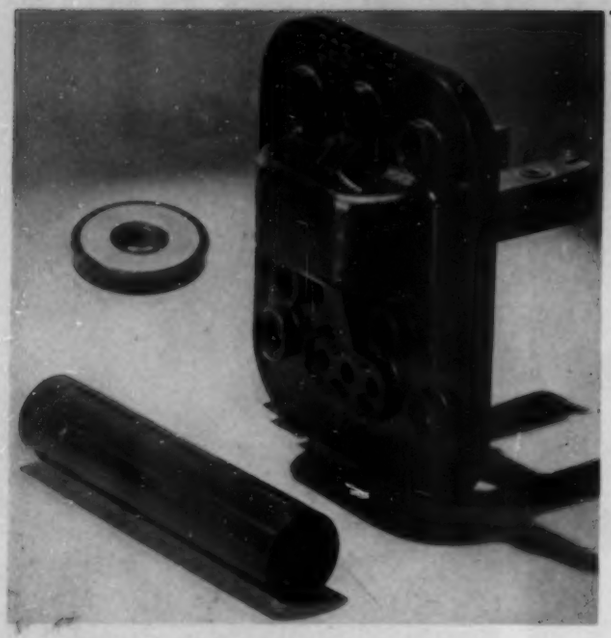
In the group of heat-resistant materials, new Underwriters' specifications require materials capable of resisting a temperature of 392 deg. F. for indefinite duration of time. This has caused development work which has resulted in higher heat-resistant materials. Special grades of material will withstand a temperature of 550 deg. F. for a short time. Asbestos-filled compounds have been given increased shock resistance and improved molding qualities, enlarging their use effectively.

A special grade of acid- and water-resistant material supplied by one manufacturer has decreased elongation or distortion generally experienced by plastics of all types when subjected to continuous immersion.

Molding around large metal inserts has always been a problem. One phenolic manufacturer recently developed a molding material which seems to have sufficient elasticity to compensate for the strains which are set up during unusually severe service conditions.

Another manufacturer has produced an unusually good molding compound for parts on which subsequent machining operations are necessary. The life of drills, cutters and other tools used has been increased by 200 or 300 percent.

Transfer or extrusion molding has come into extensive use for producing extremely strong, dense and complicated moldings. Special phenolics with extremely long-flowing characteristics are available to meet the special requirements of this process. These special materials are



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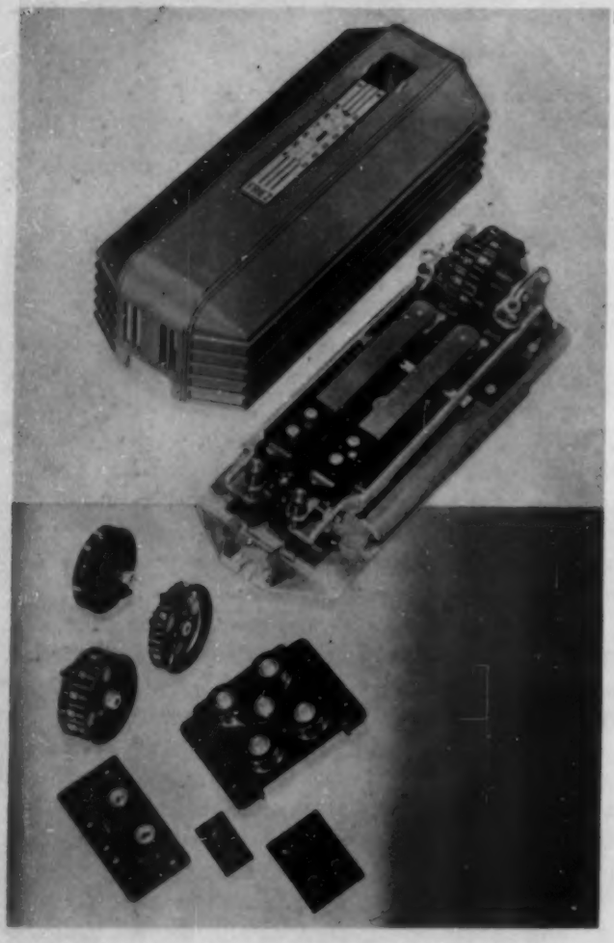

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The locomotive relay and switch parts (Fig. 7) were molded from Indur. Intricate metal inserts are molded in place with extreme accuracy. Fig. 8 shows the molded case and parts of Julien P. Friez & Sons' Dual Blade Precision thermostat. The material used is Durite

available in ordinary and translucent color. Continuous extrusion molding, as practiced abroad, has not yet been realized in this country but it is a fairly safe prediction that its development is not far off.

Perhaps the greatest advance made in the phenolic field is in the fund of knowledge which the manufacturers have amassed regarding their own materials. Actually, this is of exceptional importance. One might well ask, "Haven't they been gathering knowledge for years?" The answer, of course, is in the affirmative. But it appears that there have been more modifications made, in what were considered standard materials, this past year than in previous years. A great many old formulations have been changed, some ever so slightly, to meet specific requirements.

One result has been a tremendous increase in the number of uses to which phenolic materials have been put. Another result is the increased recognition these compounds have achieved as definite structural materials, to be considered in the class of wood, steel, glass, etc.

Forms available

The varieties of phenolic molding materials available in powder and granular forms can be appreciated from the following major groupings:

General Purpose, Non-Bleeding, Heat-Resistant, Extrusion Type, High-Impact, Arc-Resistant, Closure Type, Moisture-Resistant, High Dielectric, Acid-, Alkali-Resistant, Friction-Resistant, Sanding, Buffing Type.

Method of fabrication

Phenolic molding compounds are sold in powdered or granular form and must be placed in hardened tool steel molds under heat and pressure to be formed into their final shape. The temperature may range from 280 deg. F. to 350 deg. F., while the pressure required is from 2000 lbs. per sq. in. upwards. The chemical reaction taking place, known in the trade as "cure," requires 30 seconds to 10 or 12 minutes, depending on the particular class of compound used and the shape and size of the piece.

Typical applications

Automotive parts
Electrical insulation
Telephone equipment
Corrosion-resistant apparatus
Housings
Handles
Camera cases
Closures

Outstanding properties

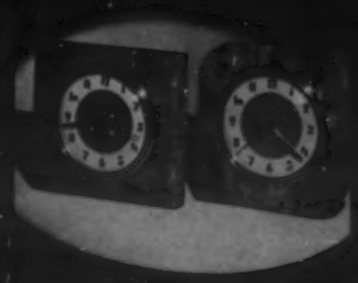
Dimensional stability
Heat resistance
Water resistance
Resistance to chemicals
Electrical insulating qualities
Moldability

Trade names

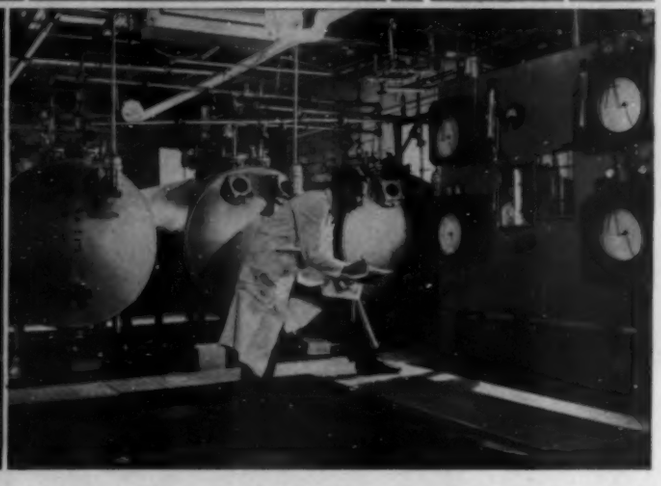
Bakelite, Durez, Durite, Indur, Makalot, Resinox, Textolite.

"Yours for the asking."

"Yours for the asking:"

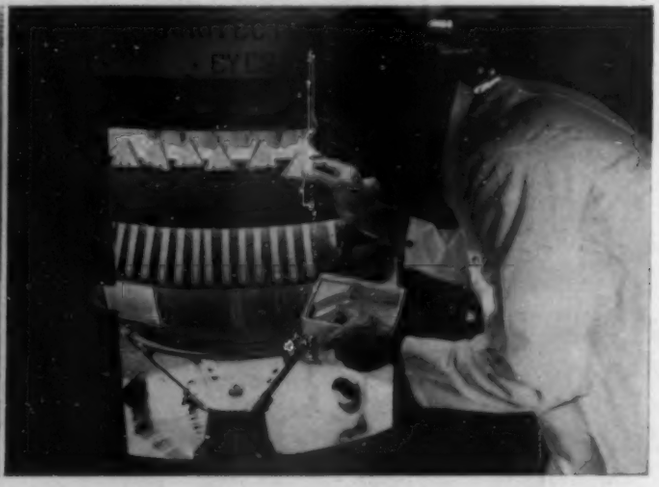


THESE CANDID CAMERA SOLVES SPECIAL (which might



1. Trial batches from analytically approved ingredients are made before commercial production is begun.

2. At every stage plastic compounds are checked and double-checked while being put through the elaborate chemical processes to insure correct results in the finished plastic.



5. The molder need not worry about this plastic, for readings made on the hardness testing machine indicate the material's resistance to deformation or distortion under load.

6. Nature now can take a rest, for it would require the sun many days to equal the effect of the powerful arc light which tests the permanence of color in plastics.

SHOTS SHOW HOW DUPONT PLASTICS PROBLEMS

be yours!)

3. The plastic must be tough to undergo tests on this machine, which registers flexural and cross breakage resistance. The tensile strength of some Du Pont plastics is as high as 60,000 pounds per square inch!

4. The "impact test" reveals the resistance of Du Pont plastics to fracture as a result of shock.

RESULT: A pre-tested Du Pont plastic especially suited for your needs. Bring us your plastic problems. We will cooperate promptly and gladly.

AMONG DU PONT'S LINE OF PLASTICS ARE:

"Pyralin" cellulose nitrate plastic; "Plastacele" cellulose acetate plastic; "Lucite" methyl methacrylate resin. These plastics are available in sheets, rods and tubes. "Butacite" polyvinyl acetal resin available in sheets. For injection and pressure molding, there are: "Plastacele" cellulose acetate molding powder and "Lucite" methyl methacrylate molding powder.

DU PONT

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PLASTICS

E. I. du Pont de Nemours & Company (Inc.)
Plastics Department • Arlington, N. J.

Shellac insulators have one great advantage in their ability to resist carbonization, and they are not as fragile as one might imagine. Those pictured here were molded by Insulation Manufacturing Company

SHELLAC

by WM. HOWLETT GARDNER*

SHELLAC, THE FLAKED FORM OF COMMERCIAL lac, is obtained from a resinous incrustation secreted by the scale insect, *laccifer lacca Kerr*. This insect is a habitant of India. The resin which it produces, has been used as a plastic from the earliest of times. Its use by Berliner in 1890 for flat disk phonograph records might be considered the beginning of the modern plastics industry. It was first used extensively for molded electrical insulation about 1900, and is still the only organic plastic binder used for very high voltage insulators.

Chemical composition

This resin is not a chemical entity. It is a solid solution of several different chemical compounds of somewhat similar structures. None of these compounds are truly resinous when obtained in fairly pure state.

The glands located in the skin of the insect produce two types of materials, a hard and soft resin when secreting the raw lac. The harder portion of lac, now known commercially as hard lac, has been separated in the laboratory into four individual fractions. The largest of these, 40 percent of the hard lac, appears to be composed of monobasic-interester-acids having the compositions represented by $C_{32}H_{54}O_9$. Equal molecular proportions of aleuritic acid, $C_{15}H_{29}(OH)_3COOH$, and a mixture of very similar acids containing a large proportion of shellolic acid, $C_{13}H_{16}(OH)_2(COOH)_2$ have been isolated from these interesters. The next largest fraction, 20 percent of the hard lac, contained monobasic-interester-lactone-acids of the composition $C_{16}H_{24}O_5$. These interesters were comprised of three acids; aleuritic acid, shellolic acid, and kerrolic acid, $C_{18}H_{27}(OH)_4$-COOH. The other 40 percent of the hard lac contained similar interesters of hydroxy acids. Some of these interesters apparently have molecular weights up to 1500.

The soft resin as it is obtained by solvent extraction has a semi-liquid consistency. This portion of lac acts as a natural plasticizer along with the wax. One fraction of it contained only a mixture of uncondensed hydroxy acids of which aleuritic and shellolic acids were found in the greatest proportions. The rest of the soft-lac contained simple condensates of aleuritic acid, an isomer of the same and shellolic acid. Natural yellow dyestuffs and wax comprise the balance of pure shellac.

General characteristics

Shellac possesses a certain peculiar combination of physical properties which make it an ideal plastic binder for a wide variety of applications. It has a relatively low dielectric constant and excellent adhesive or bonding qualities for use with fillers such as flaked mica or asbestos to produce products of particularly excellent electrical properties. It is also a unique plastic resin in exhibiting characteristics of both the thermoplastic and the thermosetting types of binders. The long period which it remains thermoplastic when heated is a marked advantage in the manufacture of certain articles. Heat-curing increases the mechanical and electrical strength. Paper laminated cylinders, for example, are cured at 300 deg. F. for several hours to develop their best properties for various electrical uses.

The greatest advantage of shellac plastics for electrical insulators is, however, their property of resisting carbonization. The gases generated when an electric arc strikes the insulating material are poor conductors of electricity and tend to turn the arc away from the composition. Shellac insulators are not as fragile as porcelain ones, and do not shatter when struck. They are also uniform throughout. Chipping or cracking the surface does not impair their usefulness to the same extent as it does with the ceramic types which depend upon a glaze for imperviousness.

Laminated compositions can be prepared by coating the paper or fabric with molten resin obtained by dusting it upon the fabric as it passes over a hot plate, or by coating it with an alcoholic solution, or with an aqueous varnish made by dissolving the lac in an alkaline solution. Shellac compositions have excellent thermal insulating properties. (*Please turn to page 98*)

* Brooklyn Polytechnic Institute.

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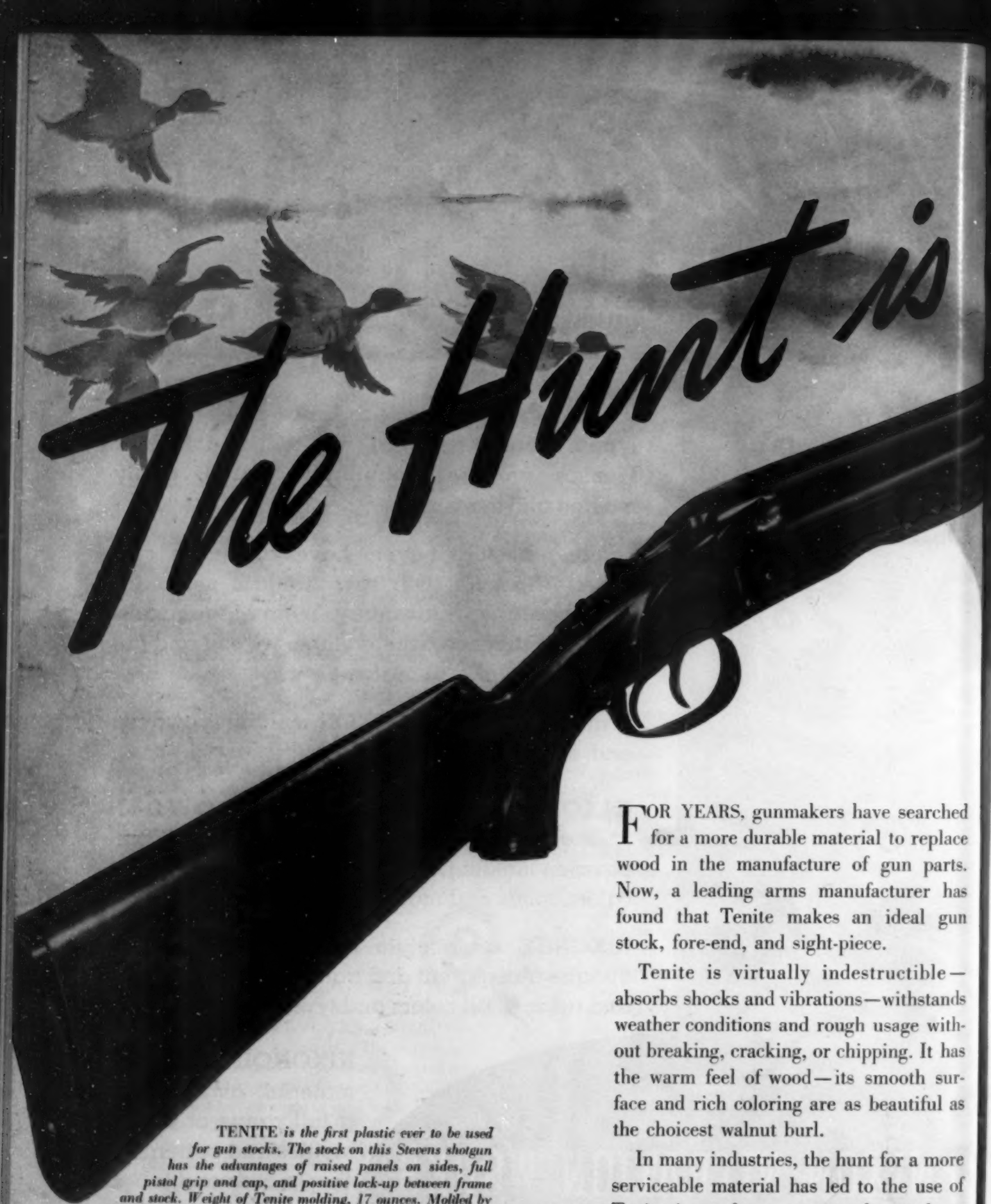

TENITE is the first plastic ever to be used for gun stocks. The stock on this Stevens shotgun has the advantages of raised panels on sides, full pistol grip and cap, and positive lock-up between frame and stock. Weight of Tenite molding, 17 ounces. Molded by Specialty Insulation Mfg. Co., Inc., for J. Stevens Arms Co.

FOR YEARS, gunmakers have searched for a more durable material to replace wood in the manufacture of gun parts. Now, a leading arms manufacturer has found that Tenite makes an ideal gun stock, fore-end, and sight-piece.

Tenite is virtually indestructible—absorbs shocks and vibrations—withstands weather conditions and rough usage without breaking, cracking, or chipping. It has the warm feel of wood—its smooth surface and rich coloring are as beautiful as the choicest walnut burl.

In many industries, the hunt for a more serviceable material has led to the use of Tenite in preference to wood, metal, or glass. In the sporting-goods field alone,

TENNESSEE EASTMAN CORPORATION, KINGSPORT, TENNESSEE

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such products as fish lures, reel ends, fly boxes, golf tees, and arrow horns are molded of Tenite more economically than they could be cast or machined in any other type of material.

Literature describing and illustrating the properties and uses of Tenite will be sent on request.

• • •

TENITE REPRESENTATIVES. *New York*, 10 East 40th Street. *Chicago*, 2264 Builders' Building. *Detroit*, 904-5 Stephenson Building. *Leominster, Mass.*, 39 Main Street ... Pacific Coast: Wilson & George Meyer & Company—*San Francisco*, Federal Reserve Building; *Los Angeles*, 2461 Hunter Street; *Seattle*, 1020 4th Avenue, South.

TENITE

AN EASTMAN PLASTIC

Subsidiary of Eastman Kodak Company

The resin is compatible with thermosetting binders such as phenol-resins and alkyds. Mixtures of lac and phenol-resins are used in the manufacture of electrical insulators which are to be employed at intermediate voltages. The properties of such mixtures depend upon the relative proportions of the two resins. Those high in lac have good carbonization resistance, while those high in the phenolic resin, show a rapid rate of cure and a high resistance to deformation by heat.

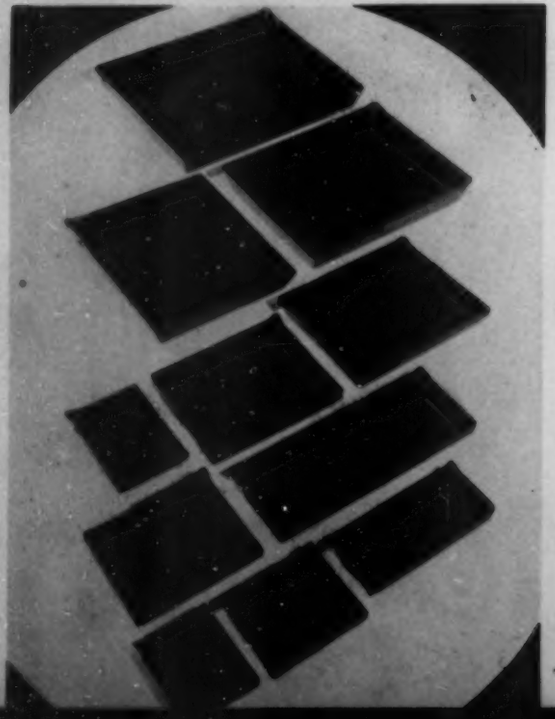
The property of high scratch hardness and resilience makes shellac an invaluable binder in the manufacture of phonograph records, especially where an accurate reproduction of over-tones is important as it is in the recording of classical music and speech. Shellac compositions also possess the valuable properties of giving a soft plastic mass which can be readily worked at temperatures of the ordinary steam-table. In pressing these compositions, they have an unusual evenness and smoothness of flow. They also take a very clear impression. Molded pieces have a high gloss and a hard surface. Wood-pitch is used as the common plasticizer. The price of these compositions is generally relatively low.

Recent developments

Research has developed several new technical methods for employing shellac. One of the most interesting of these is a special gun for applying shellac by the hot spray process. This technique of spraying molten lac has been successfully applied in the laboratory to the treatment of paper, canvas and jute in producing laminated electrical insulating tubes and boards for special purposes. The speed with which the lac can be applied in this manner has much to recommend it for plastic use.

Many of the drawbacks encountered in producing compression moldings of shellac compositions can now be overcome by employing the more recent types of injection molding machines, where small pieces can be produced at a relatively high production rate.

Photo-developing trays, ranging in size from 3 in. by 4 in. to 14 in. by 17 in. are molded in a variety of shapes by Insulation Manufacturing Company



Combining lac with urea and other chemicals not only increases the rate of polymerization, but has been shown to improve the impact strength, heat resistance and water resistance of the molded articles. Other improvements have been obtained by removing the soft-lac. Extraction of as little as 3 percent will produce a resin which will not green copper. Hard-lac shows greater water resistance, a 20 deg. higher softening point and films can be baked without causing blisters or pin-holes. Shellac molded articles are now made having softening temperatures above 212 deg. F. where formerly the same articles showed tendencies to deform below 170 deg. F.

Removal of wax improves the properties which can be obtained when shellac is incorporated in rubber. Lac has been shown to have no deteriorating effect when so incorporated but certain modifications in vulcanization are necessary. Its use has been greatly extended in this part of the plastic field. Various other modifications of lac are also being studied. Many products of new properties have been developed in the laboratory. A wide variety of colored objects can be easily made.

Forms available

Lac is not sold in forms available for molding but only as a resin for making molding composition.

The most common forms of lac are: Shellac (flakes), button-lac (flat disks), garnet lac (dewaxed slabs), needle-lac, and powder (bleached lac and dewaxed orange lac). It is also sold as alcoholic varnishes, or dissolved in alkaline aqueous solutions. Colloidal dispersions are used as hat binders.

Methods of fabrication

Compositions can be prepared by any of the methods common to preparing plastic compositions.

Molding: Compositions are usually softened upon a steam table at 225 deg. F. to 250 deg. F. They are molded at 250 deg. F. to 275 deg. F. and from 1000 to 3500 lbs. per sq. inch. Molds are chilled to 90 deg. F. to 120 deg. F. before releasing the pressure.

Injection molding can be carried out at 230 deg. F. in 1 to 2 min. for many pieces.

Typical applications

Electrical insulation (various types)
Thermal insulating board
Phonograph records
Protective coatings
Adhesives

Outstanding properties

Low dielectric constant
High dielectric strength
Arcing resistance
Adhesion
Hardness
High gloss
Resilience
Low thermal conductivity
Ease of molding
Ability to wet fillers
Oil resistance when cured

Trade names

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STYRENE RESINS

by L. E. HUMPHREY*

WITH THE INTRODUCTION OF COMMERCIAL polystyrene in this country two years ago, the plastics industry acquired a material which possesses many unusual characteristics. Many varied industries have taken advantage of the combination of properties found in polystyrene. In some cases it has opened new fields for plastics, which heretofore were impractical because of a lack of suitable materials. In others, it has improved the position of the plastics industry by doing a job better than had been done before, whether with plastics or with other materials.

Chemistry of its formation

Styrene is prepared by splitting hydrogen from ethyl benzene. The latter can be obtained from natural sources or synthesized from ethyl chloride and benzene. The styrene, $C_6H_5CH=CH_2$, is polymerized by the action of heat under conditions which will provide the desired polymer. In general the factors which influence the degree of polymerization or chain length are the temperature of polymerization and the purity of the styrene.

The rate of reaction, that is, the rate of conversion of styrene to polystyrene, decreases as the concentration of the styrene in the reaction mixture decreases. Catalysts such as benzoyl peroxide, oxygen and stannic chloride may be used to increase the rate of reaction but the resulting polymers will be of lower chain length than those produced without catalysts at any given temperature.

* Research and Development Laboratories, Bakelite Corp.

The formation of the polymer seems to be a chain reaction and not a step-wise condensation. For all practical purposes the chain length of the polymer formed at the beginning of the reaction does not differ materially from that formed at any later stage. It should be remembered that the chain length is not the same for every molecule but represents an average length.

General characteristics

As polystyrene is a thermoplastic resin, it is most easily and economically molded by the injection process. In general, higher temperatures are required for molding than those required for other thermoplastics, but the time cycles can, in many instances, be substantially reduced with polystyrene.

The high gloss and luster of polystyrene molded pieces and the ability of the material to reproduce accurately the finest details in the mold have improved the appearance of many articles. As the specific gravity of polystyrene is only 1.07, more pieces can be molded from each pound of stock. The runners and sprues can be cut and remolded, making the material economical to use.

In its natural state polystyrene is colorless and possesses an index of refraction of about 1.60. Therefore, it can be made in all colors and pastel shades, and in all degrees of transparency. These colors are noted for their non-bleeding characteristics, regardless of temperature or humidity conditions. Mottled or variegated effects are also easily obtained. (*Please turn to next page*)

Styrene, or polystyrene, as it is sometimes called, resists acids and moisture to a greater degree than most plastic materials. Therefore, the acid bottle adapter (Fig. 1) which is employed to fit the new type bottle for mineral acids, and the molded closure for Merck acid bottles (Fig. 3), are molded of styrene. Liquor pourers (Fig. 2) are finding this material suitable for their purpose. (All photos, courtesy Bakelite Corporation)

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Today's Fillers

for the

"PLASTICS of TOMORROW"

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(Above) The Theme Center of the New York World's Fair, depicting the "World of Tomorrow"

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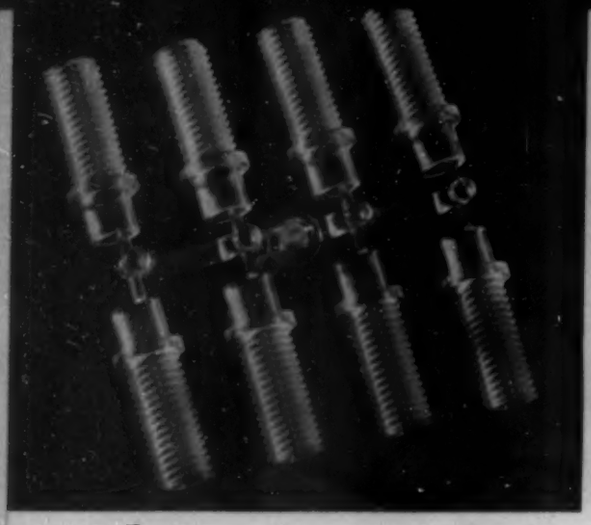

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Because of its low moisture absorption, styrene is a good insulator and is used as coil forms for RCA television receivers (Fig. 4). For the same reason, styrene was chosen to mold this transparent pill box (Fig. 5) and as impregnating agent to laminate the breaker strips in Sears Roebucks' Coldspot refrigerator (Fig. 6)

Although polystyrene is a thermoplastic resin, it has excellent stability characteristics. Its cold flow, under high loads, is practically negligible at room temperatures. At slightly elevated temperatures, it also retains its molded shape, as it has a high distortion point—78 deg C. by the A.S.T.M. heat-distortion test. These properties, with low after-shrinkage, make this material highly suitable where close tolerances must be held at slightly elevated temperatures or for long periods of time at normal temperatures.

Recent developments

In the chemical industry a great improvement has been made in the packaging of mineral acids by the use of molded polystyrene closures, because the material is resistant to high acid concentrations. Each type of acid can be quickly identified by the color of the closure. These closures eliminate contamination and make the task of opening the bottle much easier than formerly.

Another improvement in chemical laboratory equipment is the acid bottle adapter, which is designed to fit the new screw type bottle and is joined to an automatic burette. This adapter not only aids in the preparation of chemical solutions, but also eliminates the possibility of acid burns from spilling and careless handling.

Polystyrene has equally good resistance to alkalies and hydrofluoric acid. As these two chemicals attack glass, polystyrene containers are used for accurate analytical work which requires the use of these chemicals. It is likely that in a few years we may witness a complete change in the packaging of hydrofluoric acid by employing a transparent molded container of polystyrene. This material could also be used in textile equipment, battery housings, electroplating equipment, or other parts where chemical resistance, lightweight, or visibility are desired.

As polystyrene is not affected by alcohol or water and does not give off offensive odors or taste, it is used widely for molded liquor dispensers and other bar accessories. Here, color and molded design make for easy selection of your favorite beverage. Perhaps, in the future, advantage will be taken of these properties to create molded closures for bottled liquors in such a form as to improve the appearance of the package and identify the individual brands.

In the packaging field, especially in the packaging of cosmetics, polystyrene meets the requirements of beauty and utility. With its high index of refraction, with its wide variety of colors, and with its high gloss finish, polystyrene can be used in the molding of packages which present the luxurious effect we associate with cosmetics. Here, the package designer can create containers with color effects that have been unobtainable in the past except at great cost.

Polystyrene is employed for both decorative and utilitarian purposes in the refrigeration industry. Inasmuch as it does not become brittle or lose strength at temperatures as low as −30 deg C., remains unaffected by moisture, does not give off or absorb odors or tastes, it has great possibilities for panels, knobs, dials, dishes, breaker strips, and even the interior finish or trim. Because of the numerous color and lighting effects possible, the designer of the interior of the future refrigerator will certainly take advantage of these properties. A step has already been taken in this direction by one manufacturer with a polystyrene control panel, compartment front, and decorative name strips. The letters and numerals are molded directly into a crystal clear piece. They are then filled with white paint and the back is painted with a delicate shade of blue. By this process the letters and numerals are easy to read and the molded panel produces an entirely new color effect for the refrigerator interior.

One of the unique properties of polystyrene is that it is capable of transmitting and carrying light through curved sections. This characteristic is employed in the

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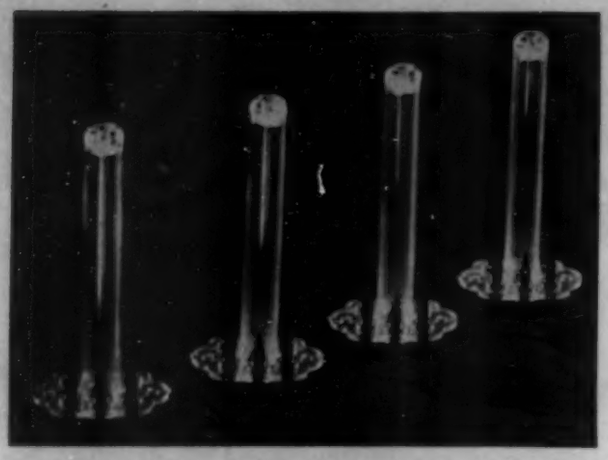

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More styrene coil forms for RCA television are shown in Fig. 7. One of the unusual properties of styrene is its capability of transmitting light through curved sections and the styrene rings (Fig. 8) are used for indirect aircraft instrument illumination. The meat storage front and decorative trim of this refrigerator (Fig. 9) are molded of transparent styrene with letters and numerals molded into the piece

illumination of aircraft instruments. By using polystyrene, a difficult problem in design was solved, as the material not only had to be capable of carrying light but had to withstand tropical temperatures without distortion. This was accomplished by the use of a split ring to carry the light and transmit it through an annular ring, called the *window*. Such a design provides adequate illumination of the instrument without blinding the pilot during night flying.

With this ability to transmit light around corners, the material is highly suitable for use in illuminated signs, automotive instrument panels, radio and television receiver panels, and, in fact, in any part desiring a practical but highly decorative design. Letters and numerals can be molded directly into the piece. Furthermore, the panel can be lighted from the back edge, providing a very novel effect as the numerals and letters seem to stand out with exceptional clarity.

Radio and television are claiming their share of polystyrene because it has the electrical properties which are not approached by any other molded plastic. With a power factor of .0002 and a dielectric constant of 2.60, polystyrene is being used to great advantage in coil forms, lead bushings, tube bases, and other parts where the ultimate in low-loss efficiency is necessary. Since the material is unaffected by moisture, the electrical characteristics do not vary with climatic changes, thus insuring constant performance regardless of weather.

One of the newest developments in the radio and television field is the use of polystyrene film in wound condensers of low capacitance. This film, with a thickness of about 1 mil, is wound between the metallic foils, providing excellent insulation. This one-mil film has a dielectric strength of over 3000 volts. When the efficiencies of various circuits are improved and the use of ultra-high frequencies becomes more general, polystyrene in various forms should play an even more important part in the field of electronics.

Forms available

Molding powders

Typical applications

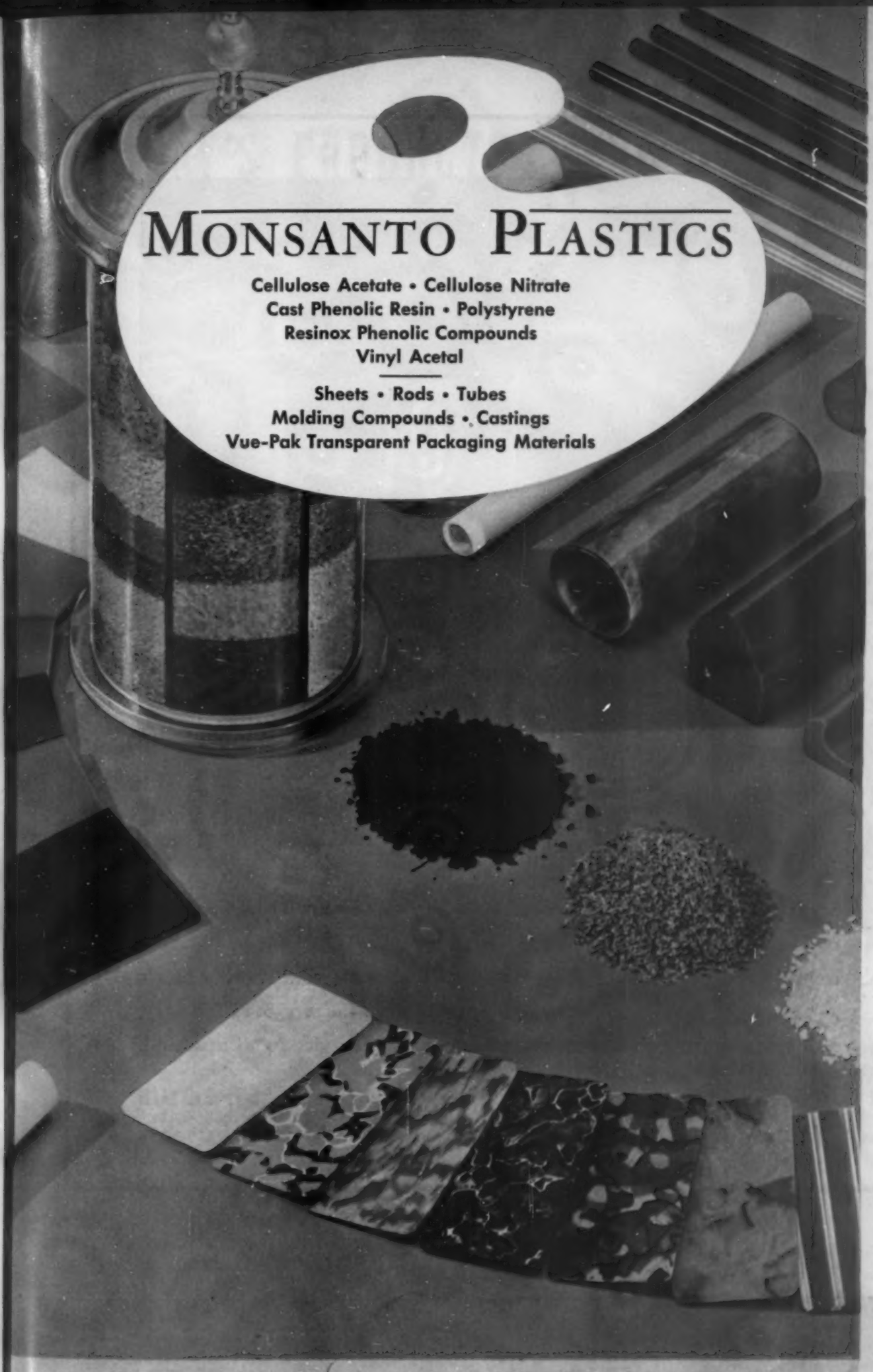
Bottle closures
Radio parts
Television parts
Refrigerator trim
Transparent automotive accessories

Outstanding properties

Crystal clarity
Low specific gravity
Electrical insulating qualities
Low water absorption
Ease of molding
Resistance to chemicals
Range of colors available

Trade names

Bakelite polystyrene, *Styron*



MONSANTO PLASTICS

Cellulose Acetate • Cellulose Nitrate
Cast Phenolic Resin • Polystyrene
Resinox Phenolic Compounds
Vinyl Acetal

Sheets • Rods • Tubes
Molding Compounds • Castings
Vue-Pak Transparent Packaging Materials

SERVING INDUSTRY . . . WHICH SERVES MANKIND

MONSANTO CHEMICAL COMPANY

Plastics Division • Springfield, Massachusetts

Every hour of every day, Industry adds to the total of human health, wealth, comfort and happiness. Without its turning wheels and pluméd smoke-stacks, our cities would be ghost towns, our farmlands would be dust bowls and empty prairie stretches. In dedicating itself to the service of Industry, modern chemistry is enlisted under the banner of service to all mankind.

MONSANTO CHEMICAL COMPANY • • • ST. LOUIS
Plastics Division • • • Springfield, Massachusetts

MONSANTO PLASTICS

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TODAY'S PRODUCTS...AND PLASTICS

NOT LONG AGO, nearly 200 businessmen in a wide range of industries were asked, "What qualities in plastics first interested you in this newest of fabricating materials?"

The replies, from men who *know* what happened to costs and sales when plastics gained a place in their products, include these typical comments:

"Eye appeal"
"Elimination of machine operation"
"Color fastness"
"Freedom from maintenance"
"No plating necessary"
"Close control of dimensions"
"Convenience in production"
"Cleanliness"
"Elimination of hand labor in finishing"
"Ease of obtaining standard parts in an irregular form"

Those qualities of plastics which are apparent to the customer in the *finished product* won the majority vote of approval. Among such reasons, all having a direct influence on retail sales, are these:

Appearance, finish, color or transparency, durability, strength, light weight, electric insulating qualities, heat insulating properties.

Production Advantages

Another group of replies deals with the element of production *inside the plant*, and includes such points as these:

Ease of manufacture, adaptability to varied uses, greater versatility allowed in product design, low first cost of materials, greater accuracy in finished parts.

Thus, it is apparent that these businessmen have found in plastics a type of material which adds sales advantages to their products while still in many cases effecting savings—often over other materials with less sales appeal.

Reading of the experience of these manufacturers, it is logical for you to ask:

"Just what are Plastics....

AN APT DEFINITION of plastics has been given by the head of Monsanto Plastics research, who said: "Plastics are materials that, while being processed, *can be pushed into almost any desired shape*—and, then *retain that shape.*"

Moldable When Softened

All plastics derive their usefulness from the fact that under certain conditions of softening—by solvents, by suspension in liquids or by application of heat—they become moldable to a desired shape which they retain.

Of course, even this is far from being a complete definition. Yet it accurately sums up the main advantages of plastics from a production standpoint. It explains why these materials, so hard and tough in their finished state, are named "plastics"... a word which commonly denotes softness and pliability.

"Plastics" a Broad Definition

The word covers a wide range of materials. In fact, rubber and glass are among the earliest of plastics—being formed easily into any desired shape during their processing, then retaining that shape after cooling. Due to the tremendous growth of newer and even more versatile materials, however, the word "plastics" now applies almost exclusively to the synthetic products of chemistry, which can be cast,

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molded or pressed into an almost unlimited variety of shapes. No one has catalogued all the textures, colors and configurations that can be attained.

Cellulose Nitrate . . . Pioneer Plastic

The first plastic to gain wide commercial use was cellulose nitrate. Today, that same material in a more highly developed form still finds countless applications—but it has been joined by many other plastics, each with its specific advantages and distinctive chemical and physical characteristics. Additional plastics are being developed constantly to meet new uses—in fact, Monsanto Plastics Division now produces a whole family of new materials undreamed of just a few years ago, in addition to the plastics it has been producing for many years.

Five Groups of Plastics

Yet, new or old, all plastics can be grouped into five main divisions. The first are cellulose plastics, derived from cotton. In this division are found Monsanto Cellulose Acetate and Monsanto Cellulose Nitrate.

The second division is made up of plastics derived from organic raw materials. Monsanto Cast Phenolic Resin is such a material.

The third—vinyl plastics which are derived from acetylene, a product of limestone and coke.

Others are derived from animal matter and from inorganic raw materials . . . including casein, urea resin and vinyl acetals.

Regardless of its basic source, each of these synthetic plastic materials owes its existence to chemists who have converted raw materials into products of wide commercial possibilities.

How Plastics Can Serve You

If you are seeking added beauty, more color and permanent color, lighter weight, speed in production, a finish that is permanent and integral, better electrical insulation, warmth and pleasing touch in the material you use, durability, a finished product that is easy to clean, elimination of intricate assembling operations, transparency or opacity or translucence —then plastics are worthy of your careful study in their relation to *your* product.

Plastics on the March

The plastics industry deserves to be rated among the fastest growing in the world. Between the time this is written and the time you read it, you may mark it down as a certainty that several developments will have occurred—in the production of new materials, refinement of existing materials and improvement in methods of fabrication.

Considering this day-to-day progress, you might say: "I will wait for more of these future developments to come along, before I look into plastics for my product." That would be economically dangerous! *Today's* plastics are at a high degree of development. And no forward-looking industry dares ignore plastics, so long as it includes men who *will* study and use them to gain leadership over competition.

Materials for Many Uses

The range of Monsanto Plastics includes materials usable in almost every industry—Monsanto Cellulose Acetate, Monsanto Cellulose Nitrate, Monsanto Cast Phenolic Resin, Monsanto Polystyrene molding compound, a group of new Vinyl Acetal Resins, Vue-Pak for transparent packages.

Of these plastics, the widest commercial uses are made of cellulose acetate, cellulose nitrate, cast phenolic resin and Vue-Pak, and later detailed discussion of materials will be limited to these, although the others are available and doubtless will find equally wide commercial application in time.

Supplied in Many Forms

Monsanto Plastics are supplied to fabricators and manufacturers in a great variety of commercially usable forms—standard sheets, continuous rolls, rods, tubes, molding compounds and slabs and special shapes—thus, there is available a variety of materials.

FIFTY YEARS OF DEVELOPMENT

SO MUCH HAS BEEN SAID AND WRITTEN in recent years about plastics development, and these materials have gained such general use during the last decade, that it is often assumed plastics are an "infant industry."

Far from it!

There is evidence of early plastics fabrication in the time of the Roman Empire, with records of a flexible glass-like material.

For all practical purposes, however, it may be declared that the present-day plastics industry was launched more than fifty years ago—which still is about forty years earlier than the average citizen realizes.

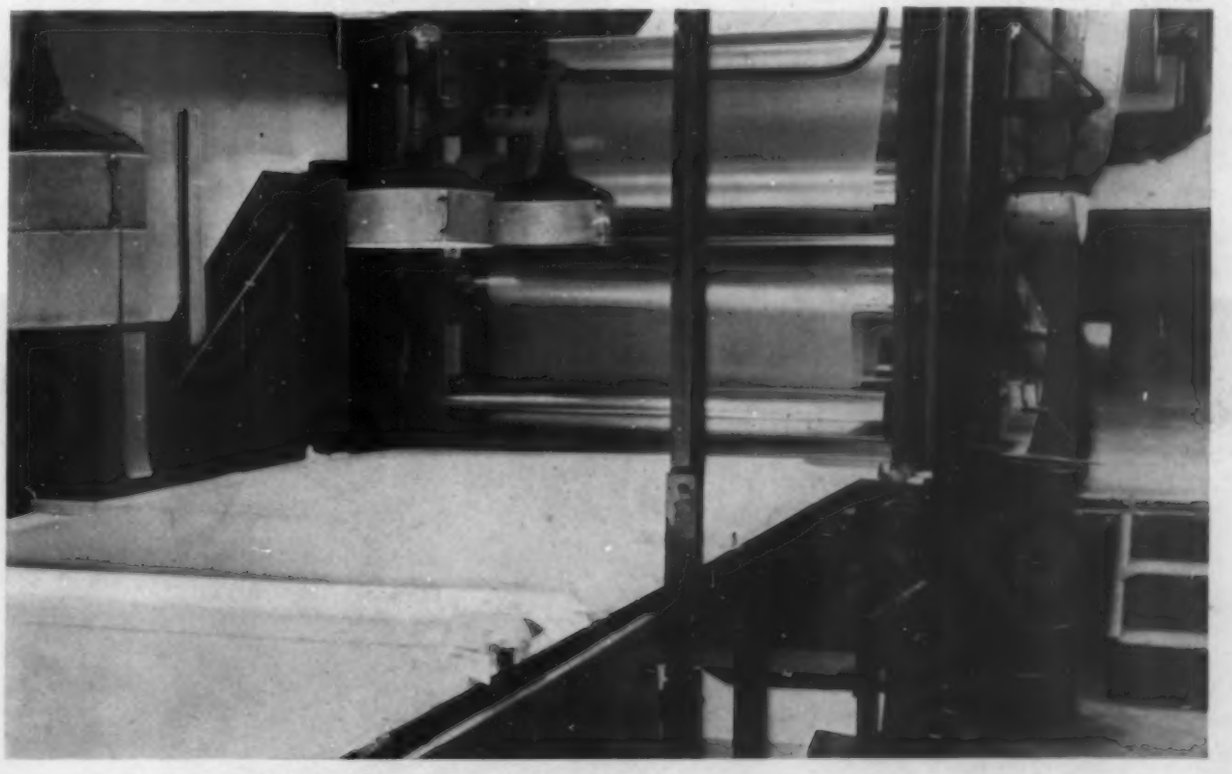
Since the Plastics Division of the Monsanto Chemical Company had its origin in these "dark ages" of the industry in the 1880's, the record of its own growth really parallels the history of plastics in general.

In 1892, a modest little plant was operating at Newburyport, Massachusetts . . . the embryonic Fiberloid Corporation. Later it was to become one of the leaders in the plastics industry and, early in 1938, was to unite with the Monsanto Chemical Company as Monsanto's Plastics Division.

Research Brings Progress

The year 1904 found the lusty young company packing up, bag-and-baggage, and moving to a new plant it had built on the banks of the Chicopee River, a few miles east of the center of Springfield, Massachusetts.

There it settled, confident that it had ample room for future growth. That belief seems somewhat humorous today, when the original Indian Orchard plant is seen nested in the broad sweep of buildings which today comprise the Plastics Division. From a



A view of the Monsanto process for production of transparent safety glass plastic in continuous rolls.

MONSANTO PLASTICS

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few hundred feet of floor space in 1904, the plant today has grown to cover more than fifty acres of floor space in more than fifty buildings.

And Then—Safety Glass!

It was here that cellulose nitrate, still a major staple among plastics, ceased to become the company's sole product and became one of a *family* of plastics products. And, from this plant on the banks of the Chicopee, came one of the major developments in all plastics history—the perfection of cellulose acetate in *continuous rolls* for automobile safety glass.

It required years of research, and the development of new machinery to produce cellulose acetate transparent sheeting in the form of continuous rolls, like newsprint. But the result is a process regarded as one of the premier processing methods of the plastics industry.

A Contribution to Every Motorist

Had the motor car industry been forced to rely on its safety glass plastic being produced only in standard-size sheets, with accompanying wastage of material, it is doubtful whether the protection afforded by safety glass would be so universal today. Certainly, it would have continued to add many dollars to the price of automobiles over today's low cost.

This is not by any means the only "first." So far as all obtainable records show, the first fountain pens of plastics were fabricated from material produced in the Springfield plant. Likewise, this plant originated the application of phenolic resin castings for radio cabinets—and this gem-like material almost instantly won a major place for itself in this application.

One of the most exacting requirements for any plastic is in its use for transparent drawing instruments. In such products, there must be no shrinkage or distortion. Ninety per cent of the plastic materials for such instruments is produced by Monsanto's Plastics Division.

A Fundamental Policy

Long ago the organization established the major policy of producing only plastic materials from which others can fabricate finished products, and to devote every research and production energy to this purpose.

This means that Monsanto Plastics are not in competition with the fabricator or manufacturer who produces finished articles from the basic plastic materials he buys from Monsanto. These are plastics for fabrication *by the trade*. . . not finished plastics articles to be sold to the ultimate consumer.

One Main Objective

None of Monsanto Plastics' research or production energies are diverted from the main objective of producing the finest quality plastics materials possible—and the wisdom of this policy is shown by the long list of customers, both custom fabricators and nationally known manufacturers, who have dealt *exclusively* for many years with this plant.

BELOW: General view of Monsanto Chemical Company, Plastics Division, plant at Springfield, Massachusetts.
INSET: Partial view of new plant for production of vinyl acetals, which adjoins buildings shown in large picture.

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Such has been the growth from the small plant in Newburyport, to one of the largest plants in the world devoted exclusively to production of plastics.

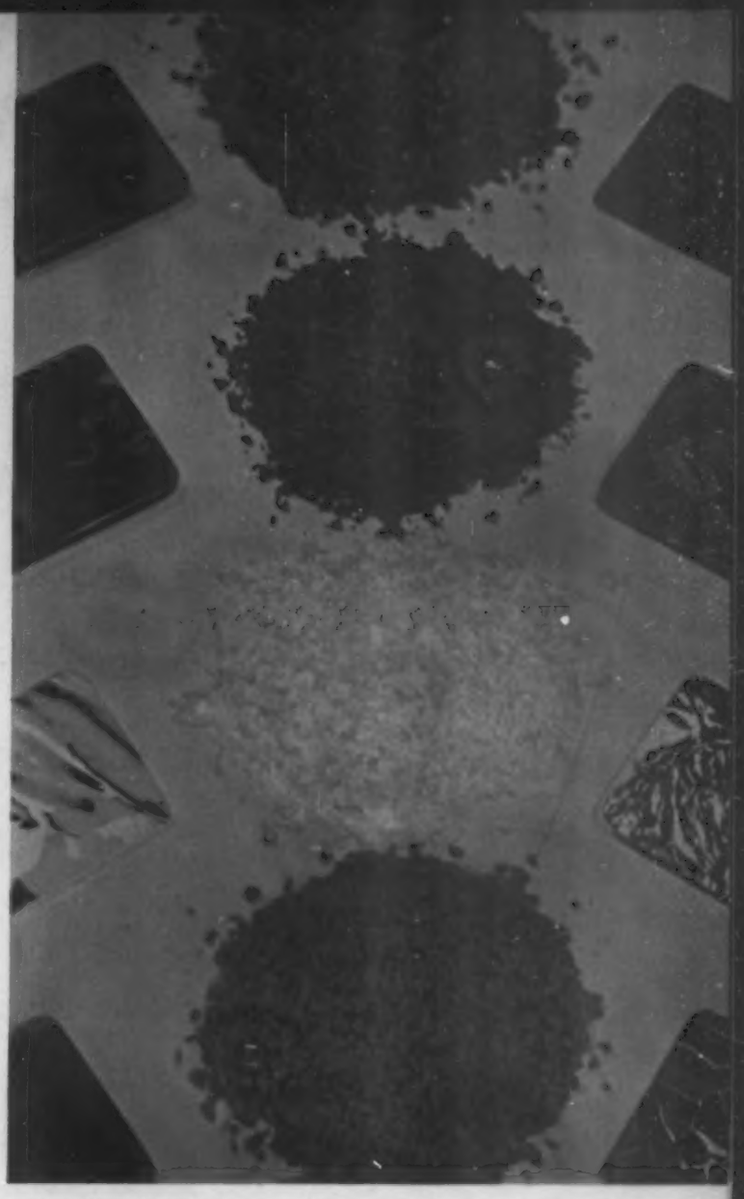
Development has followed development as surely as one note follows another in a symphony. And it has been progress so swift that it could be *seen* and *measured* . . . from the early beginning with one plastic material to production of materials in almost universal use in countless industries, all within a scant fifty years.

In 1938, this plant became one of the twelve chemical production units in America and Great Britain that form the Monsanto Chemical Company.

A Record of Growth

While this sketches the growth of only one company in the plastics industry, its development has been in step with the constant expansion of the industry as a whole. Others have made equally notable advancements in the production of materials and the perfection of processes, at the same time the Plastics Division was pioneering the developments outlined here.

It has been through versatility in materials and methods that the plastics industry has grown. Well over 100,000,000 pounds of plastics are produced yearly by this industry. It is estimated that the value of fabricated articles exceeds $150,000,000 annually —and each year's total in pounds and dollars grows larger as additional materials and uses are developed. Within six years the industry has increased its volume 50 per cent.



ABOVE: Monsanto Plastics molding compounds, in granules or slabs, provide an infinite range of solid colors or mottles.

MONSANTO PLASTICS

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Monsanto Plastics serve in the bathroom, as well as in every other room of the home. Millions of brushes gain added beauty through use of these colorful plastics.

MONSANTO PLASTICS
—their characteristics and advantages

IT HAS BEEN SAID that "plastics is a drug store business," meaning that the plastics manufacturer must compound his materials like druggists' prescriptions, to meet the individual requirement.

Although new formulas are not required in each new use of plastics, the majority of applications do call for materials that are custom-compounded to meet individual needs.

Basically, however, all the needs for plastics are met by a comparatively few materials—adjustments in formulas or variations in form of the material multiplying into a list bewilderingly long.

Designed for Sales Appeal

Of the basic plastics, Monsanto has chosen to concentrate on the production of those most closely linked with the *appearance appeal* in finished products. In other words, Monsanto Plastics include those materials most readily usable by manufacturers in increasing sales appeal.

These plastics are divided into two groups—thermoplastic and thermosetting materials.

What are Thermoplastics?

Thermoplastic materials are plastics that can be formed into desired shape under heat and pressure—

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Style steps forth in plastics. Here are durable heel covers, solid heels, shoe forms, even shoe eyelets . . . of Monsanto Plastics in gay colors or lustrous black.

that derive their rigidity by chilling while still in the mold—and that can be remolded into any other desired shape at any time by being subjected to the same conditions of heat and pressure.

Of course, no everyday use of a finished plastic article ever will bring it into contact with the high temperatures of the molding process, so this cannot be counted as a disadvantage. The practical advantages are that thermoplastics lend themselves to a fast cycle of molding or shaping, and offer production economies since rejects can be re-molded.

Thermosetting Materials

Thermosetting materials are those plastics which acquire infusibility under heat and pressure. Afterward, they are practically unaffected by high temperatures, and cannot be re-molded. While being fabricated, they require a short dwell in the mold—from one to fifteen minutes in most cases. This permits the chemical hardening reaction to take place. Unlike thermoplastics, which cool in the mold, thermosetting materials leave the mold at high temperature.

Different problems call for different materials. In many cases, thermosetting materials meet the requirements better than thermoplastics . . . in other cases, the reverse is true. Always, in plastics, the application determines the material.

The Monsanto Cellulose Acetate and Monsanto Cellulose Nitrate are thermoplastics; Monsanto Cast Phenolic Resin is a thermosetting material.

MONSANTO PLASTICS

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Transparent Monsanto Cellulose Acetate molding compound is used in unbreakable crystals for watches, clocks and radio dials . . . gives new utility to oil cans by adding visibility.

MONSANTO CELLULOSE ACETATE

SUPPLIED in sheets, rods, tubes, continuous lengths and molding compounds, Monsanto Cellulose Acetate is one of the most versatile of all plastics.

Infinite Range of Colors

Any color in the spectrum can be reproduced, either in solid colors or in a multitude of mottled or variegated tones. It can be fabricated into articles that are opaque, translucent or transparent.

Monsanto Cellulose Acetate is an excellent molding material—having toughness and resilience. These qualities are important in products having very thin walls or wherever freedom from brittleness is required.

Pleasing to the Touch

Ordinary temperatures up to approximately 150 degrees, Fahrenheit, do not affect products made of Monsanto Cellulose Acetate. It has low heat-conducting properties. This, combined with smooth finish, makes it desirable for use in products that come in contact with the skin.

MONSANTO PLASTICS

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Monsanto Vue-Pak, the new transparent packaging material, displays while it protects . . . puts every product into a showcase of its own.

Monsanto Cellulose Acetate is safe — rated by the Underwriters' Laboratory Re-examination Service in this manner: "Hazards of this product in use are judged to be small, and in storage somewhat less than would be presented by common newsprint paper in the same form and quantity."

Quality is Safeguarded

Uniformity of Monsanto Cellulose Acetate is maintained through precise manufacturing processes. Accurate color matching is a major feature of Monsanto Plastics. Dyes and pigments are carefully selected and compounded to provide stability under all conditions of light and heat.

Aids Speedy Production

Monsanto Cellulose Acetate molding compound may be compression or injection molded (both processes being described on later pages). No chemical change is involved in the molding process, so there is no tie-up of production for curing. Trimmings can be remolded immediately with no waste.

The toughness, freedom from brittleness, exceptionally close grain and uniform texture of Monsanto Cellulose Acetate make it easy to machine with ordinary wood and metal-working tools.

MONSANTO PLASTICS

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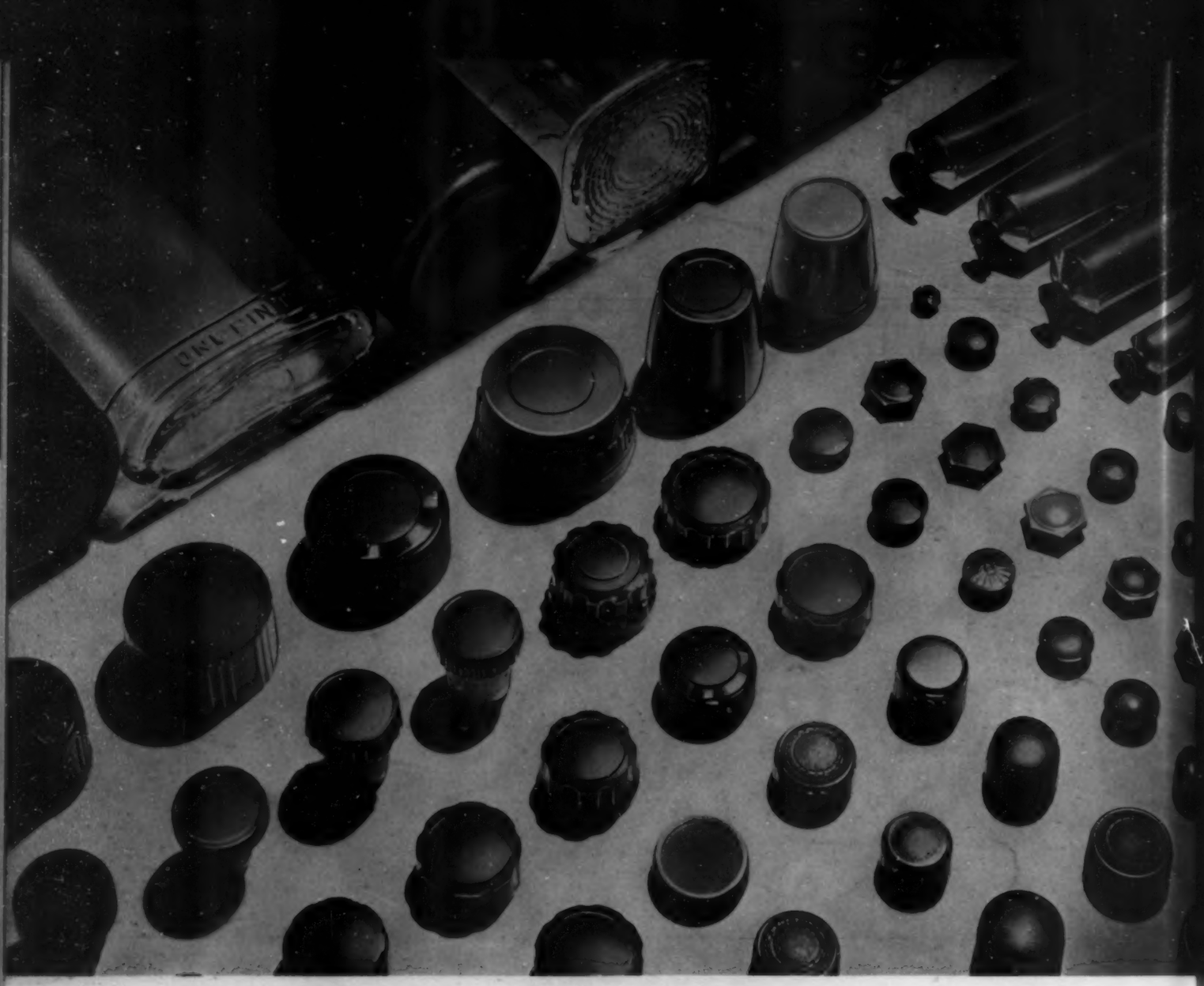

These colorful and chemical-resistant closures for bottles and tubes represent one of the thousands of practical applications for Resinox Phenolic Molding Compounds.

MONSANTO CELLULOSE NITRATE

AVAILABLE in sheets, rods and tubes, Monsanto Cellulose Nitrate is supplied in many colors or mottles. It has the characteristics of closely simulating ivory, amber, tortoise shell, semi-precious stones, wood grain and pearl.

Adaptable for Many Uses

Where flame-resistance is not a requirement, Monsanto Cellulose Nitrate is often preferred, due to its low cost, ease of fabrication and the remarkable effects achieved with it.

More than 4,000 colors, configurations and mottles are available in stock samples, and any additional effects can be matched.

Developed Through the Years

Cellulose Nitrate is a pioneer among plastics, and as a result of its long usage, many improvements have been made in its manufacture and in fabrication processes since it first found widespread commercial favor.

The long experience of Monsanto Plastics Division with this material (its first plastic) has developed a wealth of information on specialized applications which is available to all Monsanto Plastics customers.

MONSANTO PLASTICS

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Intricate parts of the popular new Magic Hanger are produced with inexpensive ease through use of Monsanto Cellulose Acetate Molding Compounds in a variety of colors.

MONSANTO CAST PHENOLIC RESIN

MONSANTO CAST PHENOLIC RESIN is a thermosetting material available in sheet, rod and tube form, as well as in special shapes.

Provides Rich, Clear Colors

It produces articles of remarkably light weight, hard and shock-resistant, non-inflammable and odorless. It takes high polish and has great dielectric strength. Colors and color combinations are limited only by the range of the spectrum.

Of all plastic materials, probably none equals cast phenolic resin in the jewel-like clarity of its colors. That is one reason why it is gaining such wide use in radio cabinets. One of the most striking results of the radio manufacturer's application of plastics has been the production of sets with Monsanto Cast Phenolic Resin cabinets, grilles made of a contrasting shade of Monsanto Cellulose Acetate molding compound, and crystal-clear dials of transparent Monsanto Cellulose Acetate sheets—three different applications of plastics in one finished product!

Handles Well in Production

In manufacturing operations, Monsanto Cast

MONSANTO PLASTICS

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Seeing is Selling!

Packages made of transparent Monsanto Vue-Pak gain the favored display positions in retail stores — combine visibility with the protection of a solid rigid container.

Phenolic Resin is machined readily in a manner similar to brass or wood. It can be sawed easily; ordinary brass-drilling equipment operates perfectly; for threading, standard taps and dies may be used.

Monsanto Cast Phenolic Resin can be heated and shrunk on metal cores or inserts; machined to extremely close tolerances; may be engraved, carved, stamped or embossed. A brief immersion in hot oil makes the material readily formable.

Other Monsanto Plastics Products

Monsanto Plastics Division produces additional materials which are not dealt with in detail here. They include Monsanto Polystyrene molding compound and Polyvinyl Acetals.

Where an application calls for one of these materials, information will be supplied on request.

Transparent Vue-Pak

Monsanto Vue-Pak, the new transparent packaging material, is another product of Monsanto Plastics. Because its applications in the packaging field are so widespread, Vue-Pak is the subject of a separate catalogue which is available on request.

Supplied in any desired weight, Vue-Pak is available in sheets or continuous rolls. It fabricates readily into any practical shape . . . enabling the products packaged within it to exercise their full eye-and-sales-appeals in retail stores.

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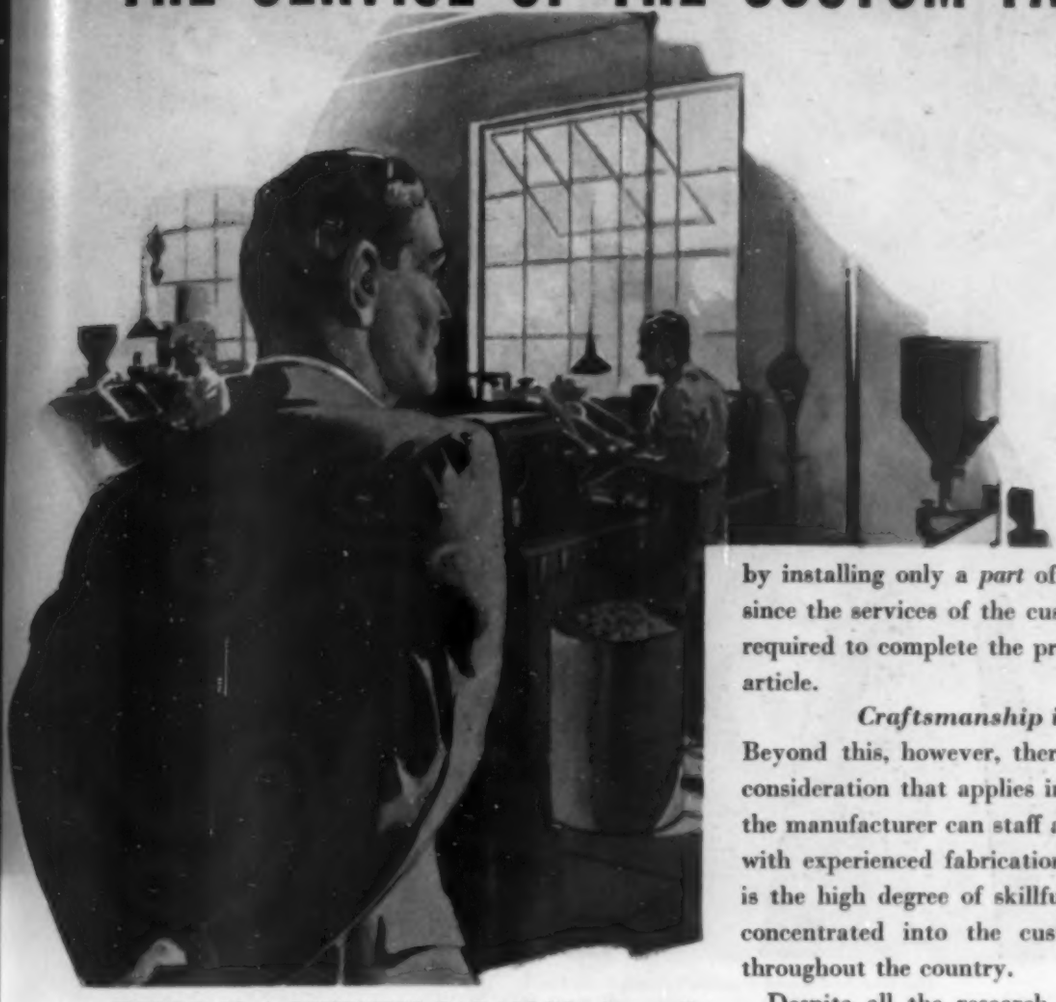
THE SERVICE OF THE CUSTOM FABRICATOR



THERE IS A BUSINESS PARALLEL that well might be drawn between the plastics industry and the field of commercial printing.

Many manufacturers have found it unprofitable to maintain printing departments of their own, due to the high cost of presses, typesetting machines and similar equipment, as well as the expense of day-to-day operation. A minority, of course, have found such a company-maintained department profitable because of the volume of printing they require.

How the Comparison Applies

The same comparison may be made in plastics fabrication. It is expensive to install the original equipment needed for an efficient molding general fabrication plant—and it is impossible to economize by installing only a *part* of the equipment needed, since the services of the custom fabricator still are required to complete the production of the finished article.

Craftsmanship is Important

Beyond this, however, there is another important consideration that applies in all cases except where the manufacturer can staff a department of his own with experienced fabrication technicians. And that is the high degree of skillful craftsmanship that is concentrated into the custom fabrication plants throughout the country.

Despite all the research efforts of producers of plastic materials, the majority of new uses for plastics originates in the plants of custom fabricators.

Experience Plus Imagination

These men and their staffs live with plastics day in and day out. They know how to attain the best results from the highly technical processes which they have mastered, exhibiting a creative imagination which is an asset both to the manufacturer who uses their services and to the producers of plastics.

In the majority of instances, the custom fabricator is the logical answer to a manufacturer's needs. Such fabricators are well distributed, geographically.

Monsanto Plastics will be happy to supply the names of competent fabricators on request.

MONSANTO PLASTICS

SERVING INDUSTRY . . . WHICH SERVES MANKIND

The color, lustre and pleasing warmth to the touch that Monsanto Plastics contribute, add much to the sales appeal of fountain pens and pencils.

YOUR PRODUCT....AND PLASTICS

It has been said if you even *suspect* that plastics might be able to make a contribution to your product, the probabilities are that investigation will show many ways in which these materials can increase sales appeal, aid in reducing production costs.

Of necessity, this discussion has dealt with plastics in general terms. Because of the multitude of industries in which Monsanto Plastics can serve, it has been impossible to point out all the applications of these wonder-working materials in the specific terms that you might have wished.

Your product may be different from others, even in its own field. Otherwise, it might not survive modern day competition. In order to see just where and how plastics might make their contribution, nothing less than individual analysis is satisfactory.

For that reason, Monsanto Plastics Division offers you the assistance of its experienced staff on any question related to use of plastics.

Inquire of Monsanto Chemical Company, Plastics Division, Springfield, Massachusetts, or any district office.

MONSANTO PLASTICS

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COMPETITIVE WINNERS

Containers made of Monsanto Plastics won top honors in the Rigid Transparent Group of the last All-America Package Competition—a tribute to the skilled fabricators using these versatile materials.

ABOVE: Martex Towel Container, made of Monsanto Vue-Pak and Monsanto Cellulose Acetate for Wellington-Sears Company, New York. Designed by Union Specialty Company, Plainfield, New Jersey.

RIGHT: Evening Bag Container, made of Monsanto Vue-Pak for I. Miller and Sons, New York. Designed and manufactured by Cleveland Container Company.

HOW PLASTICS ARE FABRICATED

USERS OF MONSANTO PLASTICS are divided into two important groups.

The largest is made up of custom or trade fabricators—firms which specialize in molding and fabricating plastics to the specifications of other companies which use them in finished products.

The second group is made up of proprietary fabricators—that is, companies that maintain their own fabricating departments and use the finished plastic articles in their own products.

Regardless of whether plastics are fabricated in a custom plant or in a manufacturer's own fabrication department, the fundamental processes are identical.

Compression Molding

The original molding process was compression molding, and it is widely used.

The most practical type of compression molding machine usually is a hydraulic press, which exerts an even pressure and closes as the molding granules or slab are reduced to the required plasticity.

While a pressure of 500 pounds per square inch is sufficient for compression molding purposes, the use of higher pressures to 3,000 pounds and more results in a quicker cycle with increased production. Thus the higher pressures are generally recommended.

MONSANTO PLASTICS
SERVING INDUSTRY . . . WHICH SERVES MANKIND

Monsanto Plastics are used in golf club faces and for covering club shafts; for the colorful new Plastees, and for covering and decorating rackets.

Molds are heated usually by steam under 150 pounds pressure, with temperature carefully regulated to the level indicated by preliminary tests on each lot of plastics material.

Injection Molding

While a comparatively recent development in molding practice, injection molding has done much to revolutionize the plastics fabrication industry. It provides a speedier method than compression molding.

This is what happens in injection molding:

The plastic material is heated *outside* the mold itself. Then the proper amount of softened material is forced into the mold chamber. The mold, being cool, permits the material to harden, after which the finished piece automatically is ejected.

Often, injection machines have multiple-molds, so that more than one article can be formed on each injection.

In the main, it is considered sound practice to mold small, quantity-production pieces by the injection method, larger objects by compression.

Other Processes

There are variations in the fabricating process for each different plastic. Vue-Pak, for transparent boxes and packages, for example, is usually formed by pressure under low heat from the flat sheets, then cemented at the joints or welded by solvents.

As mentioned, cast phenolic resin can be formed after immersion in a hot oil bath. In many instances, it is supplied also in special shapes, conforming in dimensions to the finished article, and requiring only machining and polishing after it reaches the fabricator's hands.

MONSANTO PLASTICS
SERVING INDUSTRY . . . WHICH SERVES MANKIND

Wherever eye-appeal is important, Monsanto Plastics make an important contribution. They are widely used in piano keys and for decorative effects on other musical instruments.

APPLICATIONS

Any list of applications in which Monsanto Plastics are being used is bound to be only a *partial list*. Daily, additional uses appear—evidence that the scope of plastics is limited only by the imagination and ingenuity of the fabricators and manufacturers using these materials. The list that follows indicates such versatility.

(The abbreviations, made in such form to save space and make for easier reading, are CA—Cellulose Acetate; CN—Cellulose Nitrate; CP—Cast Phenolic Resin. These indicate the type of Monsanto Plastics used in each application.)

Accordion Buttons and Trim CN—CA

Adding Machine Buttons CN—CA

Advertising Buttons CN—CA

Advertising Novelties CN—CA

Airplane Windows and Wind Shields CA

Animated Cartoons CN—CA

Automobile Door Handles CA—CP

Automobile Glare Shields CN—CA

Automobile Instrument Board Lenses CA

Automobile Side Curtains CN—CA

Automobile Lamp Reflectors CA

Automobile License Holders CN—CA

Automobile Stop Lights CN—CA

Automobile Tail Lights CN—CA

Automobile Visors CN—CA

Automobile Directional Signals CA

Baby Carriage Handles & Windows CA—CN

Badges CA—CN

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APPLICATIONS (Continued)

Bag Frames CA—CN
Banjo Picks CN—CA
Barometer Cases CP
Bathroom Fixtures CN—CA
Beads CP—CA
Belting (interlinings) CN
Billfolds CA—CN
Bird Cages CA
Blotter Covers CN—CA
Bookmarks CA—CN
Box Covers CA
Boxes—Transparent (Vue-Pak) CA Opaque CP
Bracelets CP—CA
Brushes CN—CA—CP
Brush Backs (Hair) CN—CA—CP
Buckles (Belt) CA—CN—CP
Buffers CN—CP
Buttons CA—CP
Batons CN—CA

Calculating Machine Window CN—CA
Calendars CN—CA
Campaign Buttons CN—CA
Cap Fronts CN—CA
Cash Register Buttons CA—CN
Card Cases CN—CA
Clock Cases CP
Clock Dials and Crystals CN—CA
Clothing Buttons CA—CP
Combs CA—CN
Cue Tips CA—CP
Cutlery Handles CN—CA—CP
Collar Buttons CA

Dental Plates CN
Desk Sets CP
Dials CA
Dice CP
Dictaphone Ear Cups CA
Dictagraph Mouthpieces CA
Display Forms CA
Dominoes CN—CA—CP
Display Boxes CA—CP
Drafting Instruments CN
Drawer Pulls CP
Dress Buckles & Buttons CA—CP
Drum Shells CN
Drum Sticks CN
Electric Light Shade Deflectors CA
Envelope Sealing Machine Water Holder CN—CA
Envelope Windows CA
Envelopes, transparent CA
Eyeshades CN—CA

Fasteners—Snap CA
Films CA
Fish Traps and Lures CA—CP
Florists' Tags CA
Food Covers CA
Fountain Pens & Pencils CN—CP—CA

Games CN—CA—CP
Garters, Buckles & Slides CA
Gauge Windows CA
Goggles CN—CA
Golf Club Handle Coverings CN
Golf Inserts CN
Golf Club Facings CN
Golf Ferrules CN—CA
Guitar Bindings CN—CA

Hair Ornaments CA
Hat Creasers CA

Index Forms CN—CA
Inlaid Work on Billiard Tables CN
Inlaid Work on Musical Instruments CN
Inlaid Work on Store Window Panels CN—CA

Jewelry Novelties CN—CA—CP

Key Packs CN—CA

Labels CN—CA
Lithographs CN—CA

Machine Buttons CA
Mah-Jongg Tiles and Racks CP
Mail Box Windows CN—CA
Mandolin Buttons CN—CA
Mandolin Picks CN—CA
Manicure Fittings CN—CA—CP
Map Rings CN—CA
Medallions CN
Menu Cards CN—CA
Millinery Ornaments CN—CA—CP
Minnow Traps CA
Mirror Beading to hold glass CN—CA
Mirrors CA—CN
Motion Pictures CA

Notebook Covers CA

Optical Frames CN—CA

Paint Color Cards CN—CA
Pass Books CN—CA
Pencils CN—CA—CP
Pencil Sharpeners CN—CP
Phonograph Decorative Trim CA—CP
Phonograph Records CA
Photographs CN
Photo Mounts CA
Piano Keys CN—CA
Picture Frames CN—CA
Picture Frame Windows CN—CA
Pocketbooks CN—CA
Pocket Combs CA
Pocketknife Handles CN—CA
Poker Chips CP
Poultry Leg Bands CN
Powder Puff Boxes CA—CN
Price Tags CN—CA
Plastic Book Binding CA—CN

Radio Cabinets CP
Radio Dials CA
Radio Knobs CP—CA
Rattles CN
Razor Handles CN—CA
Reel Handles CA—CP
Refrigerator Hinge Gaskets CN—CA
Refrigerator Linings CA
Rubber Stamp Handles CP
Rules CN

Safety Glass CA
Saxophone Keys CA
Shaving Brush Handles CP—CN
Shoe Eyelets CN
Shoe Forms CN—CA
Shoe Hooks CN
Shoe Interlinings CN
Shoe Lace Tips CN—CA
Shoe Lasts CN—CA
Signs CN—CA
Slide Rules CN
Stencils CA—CN
Surgical Instruments CA—CN
Switch Plates CA
Sword Handles CN—CA

Table Cutlery CN—CA—CP
Thermometer Bases CP
Toilet Seats CN—CA
Toiletware CN—CP—CA
Tool Handles CN—CA—CP
Toothbrush Handles CN—CA
Toothbrush Holders CN
Towel Bars CN—CA
Towel Racks CN
Toys CN—CP—CA
Traffic Sign Letters CA
Traffic Signal Lights CA
Transparent Windows CA—CN
Trophy Bases CP
Typewriter Keys CN—CA

Umbrella Handles CN—CA—CP
Ukulele Pegs CN

Vanity Cases CN—CA—CP

Wallets CN—CA
Watch Crystals CN—CA
Whisk Broom Holders CN—CA
Wind Shields CA
Wood Heel Covers CN
Writing Pads CN

X-Ray Mounts CA

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SKILLED HANDS AND MODERN EQUIPMENT

One of the Cellulose Dryers . . . Here purified cellulose is first dehydrated, preparatory to the many steps that will transform it into plastics.

Acid Extractor . . . After being combined with acid, the converted cellulose is whirled in a centrifugal wringer to remove excess liquid.

Partial View of Preliminary Mixing Department . . . Converted cellulose, plasticizer and solvents are mixed into a homogeneous mass. This is one of the most important stages of the process, since thorough mixing is essential to the quality of the finished plastic.

Dumping Mixture of Plastic . . . The converted cellulose has been dissolved completely in plasticizer and solvents and looks like dough.

Partial View, Roll Room . . . Here the plastic materials are kneaded by rolling into a solid mass. Color is added at this stage of the process.

General View, Cake Press Department . . . Here the material, after being rolled, is pressed into cakes for further processing.

Partial View, Sheeting Room . . . Baked cakes of plastic are secured to sheeting machines, and under tremendous power, sheets are cut from the cake in thicknesses from .003" up to ½" and over.

Partial View, Press Polish Department . . . Seasoned sheets of plastics are interlayed between polishing plates. Heat and high pressure are applied, then sheets are chilled to create permanent finishes.

Partial View, Sheet Inspection Department . . . Rigid inspections of all Monsanto Plastics assure uniformly high quality. In the sheet department, for example, every piece of material is scanned by experts.

How Plastics Rods are Made . . . Here prepared plastic is being extruded through nozzles under hydraulic pressure to produce rods and tubes in any desired length.

MONSANTO PLASTICS

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Among the many uses for transparent Monsanto Vue-Pak are its applications in the display field. The giant "lemonade glasses" in this effective display are of Vue-Pak.

MONSANTO PLASTICS—SERVANTS OF MODERN INDUSTRY

WHEN YOU SPECIFY Monsanto Plastics, you automatically gain the benefit of more than fifty years' experience in the production of plastics.

These materials are backed by one of the most experienced research staffs in the industry, and are produced in one of the world's largest and most modern plastics plants. In the hands of skilled, experienced fabricators, Monsanto Plastics have proved their merits in winning outstanding awards in national and sectional competitions of the plastics industry.

RIGHT: Products made wholly or in part of Monsanto Plastics which won five awards in a national competition in the plastics industry.

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MONSANTO CELLULOSE ACETATE MOLDING COMPOUND

DATALOGUE

MONSANTO CHEMICAL COMPANY · PLASTICS DIVISION
SPRINGFIELD · MASSACHUSETTS

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I FOREWORD

Monsanto Cellulose Acetate molding compound is a permanently thermoplastic material; "thermoplastic" meaning that the material requires heat to shape and chilling to set it in the desired form. The process has no chemical effect upon the material. Since molding of this material effects only a physical change, it can be remolded by the same process . . . an important saving since rejects can be molded again into perfect pieces.

Various formulae of Monsanto Cellulose Acetate molding compound are supplied—each having a definite thermal region in which it becomes sufficiently plastic to completely fill the mold cavity. Likewise the chilling temperature varies, but it should be noted that while with compression molding the die is actually cooled with water, in injection molding the temperature of the die is dependent, in the main, upon the piece being molded.

II GENERAL QUALITIES

DEVELOPMENT OF COMPOUND

When molding materials first came on the market, study was begun in Monsanto Plastics' laboratories to determine all the desirable qualities in a cellulose acetate molding compound, and how these qualities could best be brought together into a single material.

This study developed that cellulose acetate molding compound provides finished articles with a high degree of rigidity and toughness, low burning rate, high softening point; does not exude during intervals of injection and possesses just the right degree of fluidity or mobility to be easily molded.

However, this same study pointed out that there were certain characteristics which would have to be thoroughly understood and conquered before this plastic material would be suitable for widespread commercial molding. These characteristics were:

1. Flow
2. Setting time
3. Welding property
4. Color stability and tone
5. Color combinations
6. Manufacturing duplication and continuity

FLOW

Experience with the many molders using Monsanto Cellulose Acetate molding compound has shown that the flow characteristic of a material is the most important single factor in getting a good molded piece. To achieve the correct softness at the elevated temperature of molding and yet have the correct rigidity and toughness, was a difficult problem, but one which had to be solved.

In addition, it was necessary to understand the flow of the molten material entering the die, flowing along the runners, entering the complicated molding form and possibly being gated. This latter was not a problem that could be solved by fluid flow equations but one which had to be met by practical experiment and study.

The answer to flow problems lay in plasticizers, for it is a well-known fact that the more plasticizer used, the greater the plasticity and the greater the shock strength and elongation, but this involves a lower softening point and consequently lower molding temperature. Any lessening of the rigidity of the

finished piece had to be avoided, while lowering of the quantity of plasticizer meant possible burning of stock because of the elevated temperature which was necessary to give the stock sufficient fluidity to fill the mold.

Therefore, it was necessary to build up a tertiary system of plasticizers, correctly balanced to give high flow at the elevated temperature of molding, maintain the natural toughness of the cellulose base and finally lend it rigidity at room temperature.

Flow properties of molding compounds are controlled precisely by the ingenious Monsanto Plastics flowmeter, a device developed by Monsanto engineers. The flowmeter measures the viscosity of materials at tested temperatures, so the molder may know exactly how various compounds will flow at molding temperatures.

SET

With the molder operating in a highly competitive market, it is essential that he keep his production cycle to a minimum. To aid him, the injection machine manufacturer is continually increasing the speed of the injection, but essentially the main factor lies in the time taken for the molten plastic material to harden or set after it is in the die.

This time, as a rule, cannot be shortened by cooling the die severely, because by so doing the brilliant polish on the surface of the piece is lost.

Therefore, it was necessary that Monsanto Plastics develop a compound which would have a minimum temperature range between the distortion point and the plastic point.

The search for a material having the correct flow characteristics and ability to meet these temperature requirements resulted in a modifying plasticizer with a setting period which in actual practice has the astoundingly short period of *twelve seconds*.

A further method of increasing the speed of cycle is to increase the temperature. Although this sounds contradictory, the increase of temperature allows more shots per minute by always having the material plastic. Such treatment is possible with Monsanto Cellulose Acetate molding compound as it possesses a large range of thermal plasticity without being subject to local burning.

WELDING

Inserts, pins and circular pieces which break the plastic into two or more small streams, all introduced the problem of weld lines. The plastic stream would enter and set in layers, the outer surface of the stream "freezing" to the cold mold.

Naturally, the leading portion of the stream would cool as it flowed through a channel and retain only sufficient plasticity to be pushed along by the pressure of the stream behind it.

When two of these streams would meet at the far side of a doughnut-shaped piece, for example, the leading films of each stream were not sufficiently plastic to flow into each other. Thus they actually did not weld together and therefore had no strength. The result would be apparent on the surface of the finished piece as a line.

This problem likewise has been solved . . . the best evidence being the widespread use of Monsanto Cellulose Acetate molding compound in the optical field, where good welds are absolutely essential.

The method used in getting a satisfactory weld was to change the flow characteristic of the material from a *viscous* to a *turbulent* flow, thus preventing even a momentary formation of a hard semiplastic membrane on the leading edge of the stream of plastic.

COLOR STABILITY

Although Monsanto Plastics Division has many years of experience in the use of dyes and pigments in cellulose nitrate and acetate sheets, rods and tubes, it was found necessary to re-test all of these colors thoroughly in cellulose acetate molding com-

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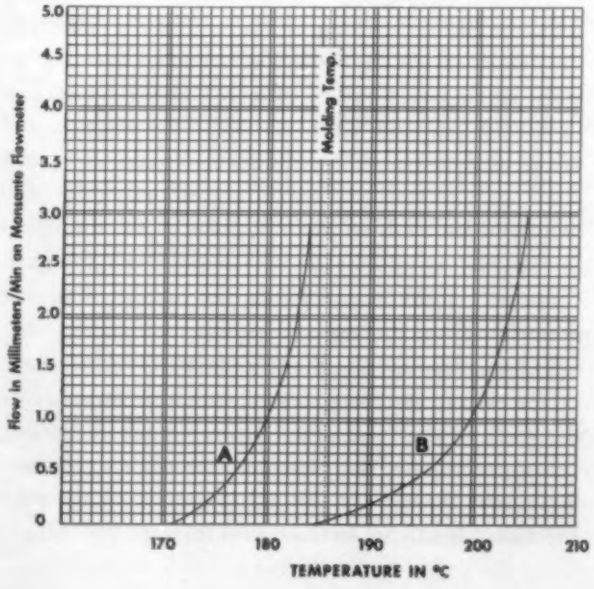
pounds since the high heat of the injection machine made some of these dyes and pigments fugitive.

To replace these fugitive colors, the dye manufacturers cooperated wholeheartedly and a new set of colors was developed and introduced. Today there are no problems on fugitive colors, since exhaustive tests show Monsanto's product will withstand more than 450° F. during injection and have a minimum life of 120 hours when subjected to actinic rays.

COLOR COMBINATIONS

In the early days of molding compound usage, only plain colors were required. However, it was not long before the interior decorator began to require accurate color matches for woodwork, or two and three color mottles to match the shades used in a room or in the article to which the molded piece was to be attached. These mottled pieces called for a new method of manufacture. The method developed by Monsanto can best be shown diagrammatically.

As shown in this diagram, a mottle would be formed, having B imbedded in A, the former retaining almost its original identity as a 5/16 or 3/16-inch piece. However, as B is softened to bring it to the left, it begins to become more and more of a streamer in the finished piece—finally losing its identity completely and fading into A. Although this system is fundamentally simple in mottles having several different colors each in a different configuration, difficulty of making an exact match increases. For this reason, though the molder as a rule mixes his own mottle, Monsanto specifies the amounts of each material and, as nearly as possible, the temperature at which it is to be molded.



PRODUCTION

In order to have material uniform throughout a batch and to duplicate the original material in each subsequent batch, great care has been taken in safeguarding every step in production of Monsanto Cellulose Acetate molding compound. It was found necessary, not only to produce a material which is completely colloided, but also a material in which the plasticizer had already become active in every phase into which it might possibly enter during the molding process.

The care in manufacture prevents any entrance of dirt, dust or other extraneous material during processing and eliminates any possibility of metal entering. However, to provide double assurance on the latter point, a large continuous magnetic separator has been installed.

Following this magnetic treatment, a magnetic shaking table removes all large pieces of the compound, giving the customer the size material which he has ordered and no oversize pieces which might not soften satisfactorily.

This brief outline of the production processes of Monsanto Plastics Division shows the care used to provide the molder with a material which will give complete satisfaction.

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III PRINCIPLES OF MOLDING

A—INJECTION METHOD

Injection machines are not a new invention but are rather an adaptation to plastics of the older machines used in die casting of metals. However, familiarity with die casting, although an aid in handling molding compounds, does not assure success in handling them. Plastic molding involves a specialized technique of its own.

Preheating Compound

It has now become standard practice among molders to preheat the compound. This removes any danger from moisture absorption which may have occurred during very humid weather. Preheating is usually done in trays set in a drier. Temperatures in the drier are maintained at 70° to 80°C. depending on the time of heating and the efficiency of the drier. The heat used in preheating is not lost since Monsanto Cellulose Acetate molding compound is not a ready conductor, and thus retains temperatures while in the feed hopper and reduces the consumption of heat while in the heating chamber.

Introduction of Compound

The molding compound is fed to the heating chamber by means of a measuring device actuated by the injection ram. The material drops into the cylinder which is left free by the ram as it moves away from the heating chamber. On the return stroke the compound is pushed forward into the heating chamber. If an unusually large charge is desired, the compound can be packed into the cylinder by manual force; however, this procedure is not recommended, and as a rule will not be necessary. Amounts of material smaller than a full load can be controlled by a measuring cup.

The heating cylinder is designed to give efficient heat transfer to the compound by means of a torpedo-shaped insert, the material passing between the torpedo and the wall of the heating cylinder. A nozzle attached to the front of the heating cylinder compounds the material separated by the torpedo and conveys the plastic from the heating chamber to the mold through a gate and runners, the desired plasticity being maintained by the set temperature of the heating chamber.

This nozzle also serves another purpose—forward tapering to the small orifice outlet sets up a back pressure which causes the fresh compound in the heating chamber to be reduced to a plastic state and, in addition, prevents undue leakage.

With the chamber and nozzle filled, the plastic mass is forced into the die by the fresh charge from the hopper. This fresh charge is forced against the plastic mass by the injection ram, activated by a hydraulic pressure of from 800 to 1000 pounds. Each repetition of this injection process constitutes an injection cycle, the stroke of the ram filling the mold and replacing this molded material by fresh compound.

Introduction of Plastic to Mold Cavity

The nozzle, which joins against an elliptically shaped hole in the mold (especially machined so as to exactly fit the forward end) is in position to allow the plastic mass to be forced into the mold by the ram. The mold is designed with a tapered entrance or gate, leading from the orifice opening at the end of the nozzle to the center of the die, where it branches into one or more small paths called runners. These runners in turn lead into the mold cavities. The position and design of these runners are important, since they must allow speedy and uniform filling of the cavity and help hold the molded piece in place as the die opens so that the sprue may be withdrawn from the gate. ("Sprue" is the name given the solidified plastic material filling the tapered gate.)

Let us visualize the flow of plastic into the mold.

The ram forces the plastic through the nozzle into the gate, in the form of a continuous wave. Passing through the gate, the plastic enters the runners and flows into the cavity through a restricted opening. Frictional heat, due to the travel through the runners

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and cavity entrance, helps to maintain the plastic in a softened condition. Obstructions in the mold, such as inserts and pins, will divide the wave and chill it slightly.

The divided wave will meet again, after surrounding the obstruction, to completely fill the cavity. Air in the cavity is forced ahead of the plastic wave and must escape by means of knockout pins, sleeves or specially placed vents. If the air is not allowed to escape, it becomes compressed and causes local burning of the stock because of the back pressure, due to heat of compression, and an incompletely filled cavity.

With the cavity filled, the ram maintains pressure sufficiently long to cause the sprue to set before withdrawing. The mold is kept closed long enough to allow the molded pieces to set sufficiently to be ejected without distortion.

Mold Temperature

All mold designers and builders provide for "ports" for circulation of warm or cold water through channels in the die. A very careful study of this cooling system is made by the die designers in order that cooling be equalized throughout the die, with no dead spaces or pockets where the water can become trapped and restrict free circulation. The wise molder will provide both hot and cold water inlets for the "ports," as better results are usually obtained by actually heating the die. For instance, it is sometimes possible to heat the side of the die, which gives the surface to the molded piece, and cool the inside portion. In this way, a brilliant polish and perfect surface will be given to the article without materially decreasing the speed of the cycle.

Ejection

The molded pieces are ejected from the mold by means of suitable knockout pins, sleeves or stripper plates incorporated in the mold design. These are mechanically operated in such a manner that they do not eject the molded piece until the die has opened sufficiently to remove the sprue from the gate.

The knockout pins will bend or badly distort the molded piece if it has not obtained sufficient rigidity at the time of ejection; however, they are so placed that even though they leave a small mark, it is not apparent to the ultimate consumer. Or, if desired, such marks can be easily buffed from the surface. Naturally, the knockout pins must exert their force only on the heavy sections of the molded piece.

Handling Molded Pieces

Following ejection of the molded piece from the die, there are several ways in which it may be handled. Almost every molder uses his own method of handling so as to best suit the needs of his plant. In large plants, for instance, a continuous belt runs behind the machine and the pieces fall on it and are delivered to a fabricating department. In smaller plants, the operator utilizes his time between mold ejections by placing the still semiplastic piece on a table where it is cooled and later broken from the runners. Some molders prefer to drop the hot pieces into water so as to hasten the setting of the pieces; however, due caution should be taken to limit immersion because of possibility of warpage and loss of rigidity.

Utilizing Scrap

As mentioned in the introduction, Monsanto Cellulose Acetate molding compound is thermoplastic and all excess material can be reclaimed and re-used in future molding cycles. This is entirely practicable; but to maintain set temperatures, pressures and cycles, it is preferable to mix the reground scrap with new material of the same type as that from which the scrap was obtained, or even with slightly softer material.

To regrind the runners, sprues, vents, etc. entails very little additional expense as there are several excellent grinding machines on the market, any one of which will regrind all the scrap from 7 to 10 injection machines. In some cases there is a loss of from 2 to 3 pounds per day by leakage from the nozzle. This material should not be re-used since grease and dirt become incorporated with this stock and render it useless.

B—COMPRESSION METHOD

Compression molding is that type of molding where the plastic is placed in a heated mold, either as granules or a blank, and is softened by the heat of the

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mold. This mold is built in two pieces—a top and a bottom—which come together under pressure, compressing the plastic and melting it so that the cavity or cavities become filled. The mold is then chilled before opening to remove the molded piece.

Compression molds are used in hydraulic or mechanical presses. Usually the two sections of the mold are fastened to the platens of the press. The molds are cored so that steam or cold water may be passed through the channels in their interiors, to afford a means of heating and cooling.

Loading

The mold cavities are filled with the proper amount of material, usually while the mold is being heated. Filling the mold cavities is usually accomplished by means of a loading form which has reservoirs containing sufficient material to fill the cavities. A dump mechanism allows the granules or blanks to fall into place when the form has been put in position above the top of the cavities.

Molding Temperature

Once the compression mold is loaded and brought up to the required temperature, it can be closed slowly—usually by means of 250 to 300 lbs. hydraulic pressure. When within .025 to .050 inch of being closed, the high pressure—2500 lbs. per sq. in.—may be applied and cooling started. The exact time of heating, the temperature, the time on low pressure, time on high pressure and time for cooling will vary with different molds. Therefore, compression molding to a large part requires a series of trials to find the best operating condition for the particular job on hand. Monsanto Plastics Division is in a position to assist the molder in selecting the right type of granules or blanks for the job and to aid in finding the correct operating cycle.

Owing to the length of compression cycles, it is a common practice to have one operator run more than one press at a time. However, it is apparent that such technique as is used in phenolic molding, where as many as six or seven presses are attended by one operator, is not usually possible with molding compound because of the short cycle which can be obtained under correct conditions.

In production of molds for compression work, the experience of the many designers of such molds may be relied on. However, it is well to point out very briefly some of the important factors to be considered in mold design.

Undercuts

Although adding to the cost, and possibly increasing wear in a die, undercutting is good practice and often materially aids in the ready removal of the molded piece, particularly in the tilting head or split-mold type press.

In semiautomatic presses where ejector pins are used to mechanically eject the molded piece, there are two main causes of trouble to be avoided.

The first of these is that the material may tend to stick to that portion of the die not having the pins. To avoid this problem, the portion of the die having knockout pins should be kept somewhat warmer than the other half of the die. Another solution to the problem is to roughen the "lands" between cavities on the portion of the die having pins and smoothing the "lands" on the other portion.

The second cause of trouble is found when the knockout pins penetrate into the molded pieces, causing them to stick to the pin. The only action to be taken in such a case is to cool the molding further.

Flash Allowances

In the simple overflow type mold, the entire study of design must be based on correct flash allowance. It becomes immediately apparent that incorrect design or the allowing of poor fits at any point of the mold may cause eventual breaking or cracking of the die.

Ejector Pins

Ejector pins are placed in compression molds to assist in removing molded pieces. Some ejectors are operated by hand. Others are arranged to function when the press opens, by means of stops or lifts fastened to the ejector plate, and actuated either by lowering or raising the press. Close fits on ejector pins are essential because the soft condition of the plastic during compression molding may easily cause the material to flash around the pin so that it binds when cool, resulting in damage to the mold if not opened gently.

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IV MONSANTO CELLULOSE ACETATE MOLDED SHEETS

Molded sheets or slabs are supplied by Monsanto Plastics Division in thicknesses of .150″ to 1.0″ and in any size up to 21″ wide and 50″ long. In these molded sheets are utilized the same formulations as in molding compounds of both injection and compression types. All colors supplied in injection type can be duplicated in molded sheets.

Molded sheets are generally used in making blanks for compression molding. This method is used extensively by those molders who operate hand presses.

With this material, a single cavity mold can be operated remarkably fast. The method usually employs a heated mold in which a blank, previously softened on a steam or hot plate, is placed. Pressure is applied by lever action. The mold then is opened and the formed piece removed and allowed to cool. The same principle can apply to a multiple cavity mold and press, mechanically operated.

V FORMULAE AND COLOR DESIGNATIONS

In order to make a readily understandable and simple nomenclature for Monsanto Cellulose Acetate molding compound formulae, the following system of symbols has been devised:

VH—Very Hard
H—Hard
MH—Medium Hard
M—Medium
MS—Medium Soft
S—Soft
VS—Very Soft

Between each group, ten divisions are made so that the intermediate formulae can be graduated. For example, there is an MSI, an MS2, an MS3, etc. The position of each numeral has been worked out by a mathematical compilation of the active plasticizer content, which progressively becomes softer as the numbers increase. Useful data on some of the properties of these divisions is shown in the table on the following page.

It has also been found advisable to set up another system for the colors and color combinations. This is given in the table which follows. These numbers are assigned only to colors which are approved by an individual customer for a specific purpose. When a request is received from a customer to match a color, the sample is given an "M" number. When, however, this color is approved by the customer and the material is made in larger scale production, the permanent color number is given to it as well as the correct formula designation. The customer will be informed of this change when it is made so that no misunderstanding will arise.

		Opaque	Transl.	Transp.	Mottles
White (cream)	commencing with	1	1001	2001	3001
Red (orange, salmon, coral, cerise, pink)	commencing with	101	1101	2101	3101
Yellow (ivory, buff)	commencing with	201	1201	2201	3201
Green	commencing with	301	1301	2301	3301
Blue	commencing with	401	1401	2401	3401
Lavender (purple, orchid)	commencing with	501	1501	2501	3501
Brown (tan)	commencing with	601	1601	2601	3601
Grey (olive)	commencing with	701	1701	2701	3701
Black	commencing with	801			

Water-clear Transparent or Crystal will run from 2001 to 2099. Shell colors will run from 3901 to 3999. Pearl colors will commence with 4001. The prefix letter F will be used in front of some numbers to indicate Monsanto Cellulose Acetate slab stock and the prefix letter G will be used in front of others to indicate granulations.

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VI FORMULAE AND THEIR USES

	VH	MH	M	MS	S	VS	H
USE	This type formula is used exclusively for mottle work	Novelties Heat resistant pieces	Novelties Optical General	Thick objects General	For relatively thin objects where weld and strength are important—i. e., boxes, etc.	For thin wall castings—ferrules where good strength is desired—Good weld, high gloss	For slab and special uses
Machine	Dependent upon other stock used in making mottle	1. Lester 2. HPM 3. Leominster Tool 4. Reed-Prentice	Same as MH formulae	1. Lester 2. HPM 3. Leominster Tool 4. Reed-Prentice 5. Isoma 6. de Mattia 7. Baldwin-Southwark	All types of machines	All types of machines	Compression
TEMP. FOR MOLD	380-410° F.	380-410° F.	360-400° F.	340-380° F.	320-360° F.	300-340° F.	300-340° F.
Impact Strength	60-100 5"x½x½ Charpy Impact	over 100	.....	.....	.....	Maximum	Maximum
Distortion Temp.	75° C.	65-70° C.	50-65° C.	40-50° C.	45° C.	40° C.	70° C.
*Flow in mm per min. at 180° C.	.25	.35-.55	.45-.65	1.-2	2-3	3-5	.40-.70
Mold Shrinkage	.....	.002-.003	.002-.003	.003	.003	.002	.005/in
Water absorption 48 hrs. at 20° C.	1-2%	2.7-1%	1.60-2.90%	2.60%	2.60%	2.60%	1.4%
Wt. loss at 100° C. for 48 hrs.	.1-.5%	.5%	.5%	.6%	.7%	.7-.8%	.5%

*This flow is obtained on the Monsanto thermoplastic Flowmeter, a machine especially designed by Monsanto Plastics Division for research in thermoplastic materials.

VII GENERAL PROPERTIES

It is not possible to give a complete table of properties of Monsanto Cellulose Acetate molding compound, for properties will naturally vary from formula to formula. However, in the next table are listed most of the essential properties, giving ranges that embrace nearly all standard formulae. If further specific data is required, your inquiry will bring complete details.

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MECHANICAL PROPERTIES

Specific Gravity	1.27-1.63
Specific Volume, cubic inches per pound	21.8-17.0
Weight per Cubic Inch (based on sp. gr. 1.3)	.047 lb.
Refractive Index N_D	1.47-1.5
Compressive Strength, lbs/sq. in.	11,000-16,000
Tensile Strength, lbs/sq. in.	4,000-5,000
Elongation	10-48%
Flexural Strength, lbs/sq. in.	5,200-8,800
Impact Strength, Inch Pounds, Charpy notched specimen, per sq. in.	3-12
Modulus of Elasticity, lbs. per sq. in. x 10^5	2-4
Impact Strength, Inch Pounds, Charpy A. S. T. M. No. 4 unnotched specimen	Over 100
Brinell Hardness (10 kg.load)	6-7.5
Scratch Resistance, Bierbaum Micro-character	5.4-12

MOLDING PROPERTIES

Type	Thermoplastic
Molding Qualities	Excellent
Compression Molding Temperature	250-350° F.
Compression Molding Pressure, lbs/sq. in.	500-5,000
Injection Molding Temperature	300-500° F.
Injection Molding Pressure, lbs/sq. in.	3,000-30,000
Compression Ratio	2-2.8
Tendency to Cold Flow, Room Temperature	None to Very Slight
Mold Shrinkage (Cold Mold to Cold Piece):	
Injection	.002-.003"/inch
Semi-positive	.005-.007"/inch
Flash	.008-.009"/inch
Extruding Qualities	Excellent
Molding Methods Applicable	Lends itself readily to all forms of dry hot molding.

THERMAL PROPERTIES

Burning Rate, .060" thickness	1.5-2.0"/minute Slow Burning. Approved by Underwriters' Laboratory.
Thermal Conductivity, 10^{-4} calories per second per sq. cm./1°C. per cm.	5.4-8.7
Flash Point, °C.	530-540
Specific Heat, calories/1°C./gram	0.3-0.45
Thermal Expansion, 10^{-5}/F.	8-9
10^{-5}/C.	14-16
Resistance to Heat, °F. (continuous)	140-180
Distortion Under Heat, °F.	122-155
Softening Point, °F.	140-175

ELECTRICAL PROPERTIES

Volume Resistivity ohms/cms. (50% R. H.)	(4.2-6.2) x 10^{12}
Breakdown Voltage, 60 cycles, volts/mil (instantaneous)	800-850
Dielectric Constant, 60 cycles	5.8-6.0
10^6 cycles	4.4-4.7
Power Factor, 60 cycles	.042-.058
10^6 cycles	.038-.042

CHEMICAL PROPERTIES—PHYSICAL PROPERTIES

Odor	None
Taste	None
Effect of Age	Slight Hardening
Effect of Sunlight	Practically None. Fades Some Colors.
Effect of Ultraviolet Light	Slight. Fades Some Colors.
Effect on Metal Inserts	None
Light Transmission. .060" gauge, colorless	85-92%
Effect of Weak Mineral Acids	Slight
Effect of Strong Acids	Decomposes
Effect of Weak Alkalis	Slight on Short Exposure
Effect of Strong Alkalis	Decomposes
Water Absorption, 24 hrs. immersion, ASTM method	1.4-2.0%
Moisture Transfer, .020" gauge, grams/square meter/day	35-150
Solubility: Soluble in	Low molecular weight esters Ketones Hydroxy esters Tetrachlorethane Ethylene dichloride alcohol mixtures
Softens in	Alcohol Esters
Swells in	Chlorinated Hydrocarbons
Insoluble in	Aromatic Hydrocarbons Aliphatic Hydrocarbons Animal Oils Mineral Oils Vegetable Oils Ethers

Color: Available in an extremely wide variety of transparent, crystal, translucent, pastel and opaque colors, as well as many mottles, pearl and ornamental configurations.

Form: Powder and Molded Slabs

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VIII HOW TO ORDER

When ordering Monsanto Cellulose Acetate molding compound or requesting samples, it is advisable to furnish ample information so that the most appropriate material for your purpose may be supplied.

The following information is desirable to avoid errors and consequent disappointment:

Color: A simple designation of color may be sufficient, but if practicable, always supply a sample to be matched. If this is not possible, request Monsanto Cellulose Acetate molding compound samples from which the exact color and degree of translucence may be selected. When mixtures or mottles are wanted, please describe them as accurately as possible. For example—"Blue white variegation, white predominating, occasional deep blue striations." Monsanto Cellulose Acetate colors are numbered when supplied; please use the number when re-ordering to insure an exact match.

Flow: For most applications, medium-soft flow degree is best. It will be furnished unless a different flow is specified. If experimentation has suggested the advisability of a different flow, be sure to specify it on the order.

Form: The coarseness, or fineness, of the granulation of Monsanto Cellulose Acetate molding compound is determined by the mesh of the screen through which it will pass. Available standard sizes run from 3/16″ to 5/16″. Unless otherwise specified, 3/16″ will be furnished.

Application: Particularly on initial orders it is advisable to briefly describe the product to be molded and whether the injection or compression molding process is to be used.

Machine: It is always best to specify what make of machine is to be used, for it has been found that there can be as much variation from machine to machine as between die to die. This does not mean that any machine is preferable to another for use with Monsanto Plastics, but rather that each varies from the other in the speed of injection, length and type of heating chamber, and other factors.

Inserts: Pins and inserts generally present their individual problems and if it is possible to describe how these are placed, spaced or used, it will simplify the selection of proper material.

Welding: If exceptional welding problems exist these should be explained, since standard materials might not be satisfactory in such special cases. An explanation of the problem will bring you the best compound to meet it and still provide satisfactory results.

IX HOW TO STORE

Monsanto Cellulose Acetate molding compound is packed in bags and shipped in fibre boxes. The hazard of dust and dirt in the storing and handling of molding material is always a serious one, especially when pure colors, or transparent or translucent effects are to be obtained in finished products. For this reason, the utmost precautions should be taken at all times. Always keep Monsanto Cellulose Acetate molding compound in a clean, dry place. All containers should be kept tightly covered.

Uncompounded cellulose acetate flake absorbs from 5 to 8% moisture from an atmosphere of 80% relative humidity. While this tendency is much reduced in Monsanto Cellulose Acetate molding compound, there may be a slight moisture absorption from very humid atmospheres. For greater accuracy in molding, therefore, storage in dry atmosphere and in closed containers is essential for best results.

The ordinary precautions against combustion are quite adequate in storing. The report of the Underwriters' Laboratories reads: "Hazards of this product in use are judged to be small and in storage somewhat less than would be presented by common newsprint paper in the same form and quantity."

X APPLICATIONS

The development of injection molding has broadened rapidly the already wide field of thermoplastics. It is today difficult to name a single industry in which plastics are not coming into increasing use due to their inherent characteristics and the ease of fabrication by modern molding methods. Finished products, manufactured from Monsanto Cellulose Acetate molding compound are today found in widely varied fields, of which the following are typical examples:

AUTOMOTIVE

Dome Lights
Electrical Equipment
Gasoline Caps
Gear Shift Balls
Hardware
Instrument Panels
Window Moldings
Tail Lamps

SPORTING

Lawn Bowl Markers
Fishing Reels
Golf Tees

ELECTRICAL

Commutator Parts
Hearing Devices
Light Switches
Outlet Plugs
Switch Plates
Vibrator Combs

AIRPLANE

Hardware
Instrument Panels
Control Buttons

INDUSTRIAL

Adding Machine Keys
Motion Picture Film Cores
Miners' Lamp Housings
Oil Cups
Oil Gauges
Protective Goggles
Valve Handles
Yarn Spool Ends

HANDLES

Safety Razors
Whisk Brooms
Tools
Cutlery
Kitchen Utensils

COSMETICS

Containers
Compacts
Lipstick Holders
Jar Tops

HARDWARE

Door Knobs
Escutcheon Plates

RADIO

Dials
Cabinets
Panels
Knobs

PERSONAL

Bracelets
Buckles
Buttons
Combs
Costume Jewelry
Goggles
Hair Ornaments
Pencils
Pens
Spectacle Frames

UMBRELLA

Handles
Ferrules
Tips

XI APPENDIX

MONSANTO POLYSTYRENE MOLDING COMPOUND

Monsanto's newly developed polystyrene molding compound has entered the injection and compression molding field, not as a competitor to cellulose acetate molding compound, but rather as a material to open still added fields to molding endeavor. Where lack of alcohol resistance or interference at radio wave frequencies has been a problem previously, this new Monsanto Polystyrene has special advantages. Another advantage of polystyrene is to be found in those applications where molded pieces are subjected to extreme humidity and relatively high temperatures for long periods.

The previous description of molding machines and molding processes applies equally well to any molding compounds supplied by Monsanto—both Monsanto Cellulose Acetate and Monsanto Polystyrene.

As with Monsanto Cellulose Acetate molding compound, Monsanto Polystyrene has been withheld from the market for exhaustive study of its properties and applications. This research, now completed, enables Monsanto to provide real assistance to the molder in his handling of this important new resin.

Monsanto Polystyrene, contrasted with Monsanto Cellulose Acetate molding compound, is a synthetic resin of the Vinyl family. This new resin has many remarkable qualities, most startling of which are its resistance to alcohol, low interference at radio wave

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frequencies, low water absorption and transfer, clarity, rigidity and a wide range of molding temperatures.

The clarity of the material means new possibilities in the optical field, as one example of application. In addition, this clarity allows the material to be produced in a wide range of color tones, as varied as the imagination of the color expert producing them.

Its low interference at radio wave frequencies gives Monsanto Polystyrene an entrance into fields that have, as yet, been little developed by molding compounds. To the airplane manufacturer, it means a cowling for the radio beacon antenna which, in addition, streamlines the plane. To the radio manufacturer, a unique use of plastics in radio tubes, grilles and other parts.

The fact that Monsanto Polystyrene can be molded over a tremendous range of temperatures (from 320° to 450° F.) gives it a marked advantage. However, it is well to remember that injection molding under 370° F. is not advisable, since below this temperature the material is not made sufficiently plastic and an unmolding effect in the form of "crazing" on the surface may appear.

Two standard formulae of Monsanto Polystyrene molding compound already are in production. This is not a limitation as it would be with cellulose acetate as these two formulae, as explained previously, mold over a very long range of temperatures and have a very short set, so that the cycle can frequently be cut off below fifteen seconds. One of these formulae is Monsanto Polystyrene in practically a nascent form; the other contains a lubricant plasticizer which aids in the molding of Monsanto Polystyrene in very complicated dies. If the customer has a special application which neither formula appears to fit, and it is practical to use this resin for such an application, Monsanto Plastics Division will make a polystyrene material to fit his needs.

Experience with many molders has taught that when thick molded pieces of polystyrene are exposed to actinic rays for long periods of time, a slight yellowing discoloration is apparent which might cause the eventual rejection of the pieces. With thin pieces, this yellowing is so much less noticeable that it probably would not be apparent under even close examination. Experience also has shown that when the molded piece is subjected to heavy or continual flexure an unmolding tendency will become apparent in the form of a slight craze. These facts are presented frankly, in the belief that the advantages of Monsanto Polystyrene for many uses are so great they outweigh these minor inherent disadvantages, which after all apply in only exceptional instances.

Many consumers may feel the price of polystyrene is too high to meet cellulose acetate on a competitive market. However, if the molder will weigh a complete assembly of polystyrene against a complete assembly of cellulose acetate he will find that the polystyrene weighs approximately 17.7% less. This means that 17.7% should be subtracted from the original cost, thus making the actual cost of crystal polystyrene less than that of crystal cellulose acetate—and colored polystyrene very little more than colored cellulose acetate. Both materials — polystyrene and cellulose acetate—have great advantages in their individual fields. Both have a place in the future progress of plastics.

The following is a short list giving the properties of Monsanto Polystyrene which may be of importance to the molder:

Molding Quality	Good
Compression Molding Temperature	280-325° F.
Compression Molding Pressure	300-3,000 lbs. per sq. in.
Injection Molding Temperature	350-450° F.
Injection Molding Pressure	1,000-30,000 lbs. per sq. in.
Compression Ratio	2.5
Mold Shrinkage, inches per in.	0.002-0.0025
Specific Gravity	1.05-1.07
Specific Volume, cu. in. per lb.	25.9-27.8
Burning Rate	Slow
Effect of Age	None
Effect of Sunlight	Yellows
Effect of Weak Acids	None
Effect of Strong Acids	None
Effect of Weak Alkalis	Crazes
Effect of Strong Alkalis	Crazes
Effect of Organic Solvents	Widely Soluble
Color Possibilities	Unlimited
Light Transmission	More than 90%

MONSANTO
CELLULOSE ACETATE

SHEETS • RODS • TUBES
CONTINUOUS LENGTHS

DATALOGUE

MONSANTO CHEMICAL COMPANY · PLASTICS DIVISION
SPRINGFIELD · MASSACHUSETTS

MONSANTO CELLULOSE ACETATE is a thermoplastic material supplied in sheets, continuous lengths, rods, tubes and molding compounds.

This plastic is especially distinguished for its exceptional resistance to actinic light rays (sunlight) and its flame-resistant properties.

Duplicates the Spectrum

Monsanto Cellulose Acetate is made in an infinite range of colors, from clear crystal and pure white on the one extreme to jet black at the opposite extreme; in solid colors and in thousands of combinations of mottled, grained and veined effects. It is produced in transparents, translucents or opaques. One unusual effect is attained by producing Monsanto Cellulose Acetate in a perfect imitation of iridescent pearl.

Starts with "Linters"

The cotton which provides the cellulose base for Monsanto Cellulose Acetate is called "linters," and is the short fibre cotton not suitable for spinning.

The cotton linters are purified and bleached, washed, dried, fluffed and then compressed into bales. These linters then are acetylated; that is, treated with acetic acid and acetic anhydride in the presence of a catalyst.

This process transforms the cotton into cellulose acetate, which must then be purified to free it of excess acid. The acetylating process is extremely exacting both as to the equipment and ingredients used.

Production is Scientifically Accurate

The purified cellulose acetate is then ready for incorporating into a Monsanto Plastic. It is mixed with plasticizers or softeners, which impart flexibility to the resulting plastic. At this point, solvents also are added, to reduce the mass to a dough-like consistency.

After mixing, the plastic mass is kneaded on large chromium plated rolls, which remove the solvent and make the material compact and homogeneous.

How Sheets are Produced

After this mass is baked into a large cake, sheets are veneered from it. Monsanto standard sheet size is 20″ x 50″, thus containing an area of one thousand square inches per sheet. This makes it very easy to compute the value of any size piece cut from the sheet. Sheets are in gauges from .003″ in steps of .0025″ up to .020″, and from then on to any specified thickness up to ¾″ (or even thicker when specified).

Laminated Sheets

For some types of work, sheets are laminated together so that if the more expensive pearl effect is needed for some particular work, the pearl sheet can be made very thin and laminated to a lower priced sheet to produce the desired rigidity and thickness. This lamination may consist of almost any number of sheets in contrasting color to produce a striped edge.

Continuous Process

Monsanto Plastics Division has developed a continuous process for producing cellulose acetate in standard weights, commercial widths and any length—the material emerging in giant rolls like newsprint paper. This eliminates the waste sometimes resulting from use of standard sheet stock, where the size of the material required is less than the sheet size.

How Rods are Made

Rods are made by two methods—extruded or cut. The extruded rod is usually used for solid colors or for certain graining effects, where the graining can be parallel to the rod. Cut rods are made when block type mottles are desired in color or pattern effects that cannot be accomplished by extruding.

Cut rods are made from a block of the material by much the same veneering process that sheets are cut from a block.

Rods, either extruded or cut, are supplied as they come from the extruder or from the cutting machine, or they can be centerless ground to exact specifications if the work in hand requires that treatment.

Producing Tubes

Tubes are made by three principal methods—extrusion, spiral wound or butt weld. The extruded tubing is mostly used for solid colors, or for colors with graining effects where the grain may run parallel to the tube. This tubing can be supplied either as it comes from the extruding machine, or it can be supplied stretched and ground to exact specifications for size, both on inside diameter and outside diameter.

Spiral wound tubing, as its name implies, is made from sheet material, spiral wound and welded by a solvent under pressure. This type of tubing is used where color effects are desired that cannot be produced by the extrusion method.

Butt weld tubing is made from sheets, folded and welded with a solvent under pressure. For all practical purposes both the spiral wound and the butt weld tubes can be considered seamless. The action of the solvent used to make the joint unites them, giving them the full strength of the sheet itself.

Rods and tubes supplied by the extrusion method have a standard length of 50″, but can be supplied in other lengths when specified. Spiral wound and butt weld tubing are generally made in 30″ and 36″ lengths, but also can be supplied, on special specification, in other lengths.

Fabrication Methods

Monsanto Cellulose Acetate is fabricated by cutting, sawing, punching, drilling, drawing, molding, turning, printing, embossing and polishing. Being a thermoplastic material, Monsanto Cellulose Acetate is softened by the application of heat. It then can be drawn into an infinite variety of cup-shaped or dome-shaped items, and can be bent into desired form, as in the manufacture of transparent boxes.

These operations merely involve heating the material to a specified temperature, and placing it in a die to draw or bend, as the case may be, and chilling it while in the die under pressure.

Likewise, Monsanto Cellulose Acetate can be molded, in which case pellets of the desired size are laid in a hot die or preheated, and pressed into the desired shape under pressure of approximately 3,000 pounds per square inch of projected area of molding surface.

In this case the dies consist of upper and lower halves in which the proper cavities are provided. Outstanding and very familiar examples of this technique are typewriter keys, adding machine buttons and dentures as molded by the dental profession.

For Printing Requirements

For printing, which is a specialized industry, Monsanto Cellulose Acetate sheets are supplied in a mat finish. Printing is done with special formula inks and the printed sheet is later press polished, which makes the printing permanent and provides a smooth and glossy surface.

This operation consists of placing the printed sheets between highly polished plates, and pressing them under heat, and allowing them to chill while under pressure. By this means the polished surface of the plate is reproduced on the plastic sheet.

Monsanto Cellulose Acetate can be cemented, as in the case of certain built-up boxes, and spiral and butt weld tubing by the use of a Monsanto solvent which firmly unites the surfaces to be cemented.

Additional Fabrication Notes

Tool marks on finished fabricated products are readily polished off. The ordinary method of polishing is to use a muslin wheel with a mixture of pumice and water. The piece is then given a high lustre by subsequent operations on other wheels using rouge. Another method is to tumble-polish, and by this method certain types of products, which lend themselves to this technique, can be given a satisfactory finish. In some cases, tumble-polished pieces are given a final hand polish on a wheel, which, of course, produces a much higher gloss.

Since Monsanto Cellulose Acetate is used in an extremely wide range of applications, it is produced in many formulations, in each of which is used special ingredients which impart certain properties to meet specific requirements. In other words, it might well be termed a "custom-built" plastic designed to meet the varying needs of industry.

PROPERTIES OF MONSANTO CELLULOSE ACETATE

MECHANICAL

Specific Gravity	1.27-1.60
Specific Volume, cubic inches per pound	21.8-17.4
Density, grams/c.c.	1.22-1.62
Weight per Cubic Inch (based on specific gravity)	20.8-26.2 grams .046-.058 pound
Refractive Index N_D	1.48-1.51
Tensile Strength, lbs/sq. in.	6,000-8,000
Elongation, per cent	10-50
Bursting Strength (Rupture) lbs/sq. in.	350-450
Modulus of Elasticity, lbs/sq. in. x 105	1-3
Impact Strength, Charpy (notched) per inch square	2-7
Brinell Hardness, 10 kg. load	6-11
Machining Qualities	Very Good
Shrinkage	0.2-2.0%

MOLDING PROPERTIES

Type	Thermoplastic
Molding Qualities	Excellent
Compression Molding Temperature	180-240° F.
Compression Molding Pressure lbs/sq. in.	100-500
Preforming	Very Good
Tendency to Cold Flow	Very Slight
Molding Methods Applicable	Extrusion, Swaging, Shearing—All Good
Mold Shrinkage, inches per inch:	
Positive	.002-.003"
Semi-positive	.005-.007"
Flash	.008-.009"
Extruding Quality	Excellent

THERMAL PROPERTIES

Burning Rate	1.5-2.0"/minute (.060") Slow Burning—Approved by Underwriters' Laboratories
Thermal Conductivity, 10^{-4} calories per second per sq. cm/1° C. per cm.	5.4-8.7
Flash Point, °C.	530-540
°F.	986-1,004
Specific Heat, calories/1°C./gram	0.3-0.4
Thermal Expansion, 10^{-5}/°C.	5-16
Resistance to Heat, °F. (continuous)	140-180
Softening Point, °C.	82-190
°F.	179-374
Effect of Heat, Dry	Little or None
Moist	Slight Swelling
Heat Distortion, °C.	50-100
°F.	122-212

ELECTRICAL PROPERTIES

Volume Resistivity, ohms/cms (50% R. H.) 30° C.	(5-30) x 10^{12}
Breakdown Voltage, 60 cycles, volts/mil	600-1,800
Dielectric Constant 25° C.,	
60 cycles	1.12-3.9
10^6 cycles	4.2-5.3
Power Factor, 25° C.,	
60 cycles	0.44-1.1%
10^6 cycles	.038-.091

CHEMICAL PROPERTIES — PHYSICAL PROPERTIES

Odor	None, to Mild Aromatic
Taste	None
Effect of Age	Slight Shrinkage
Effect of Sunlight	Practically None—Some Colors Fade
Effect of Ultraviolet Light	Very Slight—Some Colors Fade
Effect on Metal Inserts	None
Light Transmission, .060" colorless	91.1%
Effect of Weak Mineral Acids	Fair Resistance
Effect of Strong Acids	Decomposes
Effect of Weak Alkalies	Slight
Effect of Strong Alkalies	Decomposes
Water Absorption 25° C. (Maximum)	3.5-5.0%
Effect of Hot Water	Softens and Swells
Effect of Cold Water	None
Moisture Transfer, gms/sq. meter/day/.005"	35-150

Solubility: Soluble in—

Low Molecular Weight Esters	Ketones Hydroxy esters Tetrachlorethane Ethylene Dichloride-alcohol mixtures
Softens in—	Alcohols Esters
Swells in—	Chlorinated Hydrocarbons
Insoluble in—	Aromatic Hydrocarbons Aliphatic Hydrocarbons Animal Oils Mineral Oils Vegetable Oils Ethers

Color: Available in an extremely wide variety of transparent crystal, translucent, pastel and opaque colors, as well as in many mottles, pearls and ornamental configurations.

Forms: Sheets, rods, tubes and molding compounds.

MONSANTO PLASTICS PRODUCTS OF MONSANTO CHEMICAL COMPANY

PLASTICS DIVISION • SPRINGFIELD, MASSACHUSETTS

MONSANTO RESINOX PHENOLIC COMPOUNDS

DATALOGUE

MONSANTO CHEMICAL COMPANY
Plastics Division • Springfield, Massachusetts

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VIII PROPERTIES OF MONSANTO RESINOX PHENOLIC COMPOUNDS

I FOREWORD

The exceptional qualities of Resinox, plus flexibility of formulas which permit compounding special materials for specific applications, have won a place for these phenolic molding compositions in practically every industry. They are used for such products as radio cabinets, where eye appeal is of major importance; as closures, where their composition must withstand chemical action of the bottle contents without loss of torque strength; in working parts of motors and electrical equipment, where strength, heat resistance, accurate dimensions and durability are paramount.

Acceptance of phenolic resins came quickly after their discovery more than 35 years ago. Among the earliest recorded uses was a tiny molded bushing, hardly an eighth of an inch in diameter, used in an electrical instrument.

Phenolics were chosen for this application to avoid the problem of insulating a metal bushing. Success of this small molding awoke industry to the possibilities of the new material. The molded bushing delivered great savings in manufacturing costs, lasted longer than metal bushings and eliminated the danger of short circuiting.

The new material soon was found to have exceptional dielectric properties and to give almost perfect insulation. Today, phenolic moldings are used in nearly every electrical device and their usefulness has extended to scores of widely diversified industries.

II GENERAL QUALITIES

Resinox molding compounds are thermo-setting plastics. That is: They react chemically under heat and pressure to produce molded pieces which thereafter are unaffected by heat.

The outstanding advantage of Resinox is that it affords rapid, low-cost production of articles or parts, which require no additional shaping and very little finishing. While the mold must be carefully machined or hand-tooled to the exact dimensions and details desired, it can be used to produce an unlimited number of molded pieces of exactly the same dimensions and with faithful reproduction of every detail.

Simplified Assembly

Expensive assembly operations often may be eliminated by molding, as one piece, an article which formerly had to be constructed from a number of parts. Ease of fabricating, reduced benchwork, rapid assembly and elimination of labor for finishing, all lower the cost of the product. Metal parts and inserts may be combined integrally with the finished piece during the molding operation.

Then, too, the lesser weight of Resinox is of considerable economic importance in modern manufacturing and shipping. (Resinox is approximately 50% as heavy as aluminum; 17% as heavy as iron or steel; and 15% as heavy as copper.)

Wide Variety of Colors

Articles, varying from closures and buttons to radio cabinets and clock cases can be molded of Resinox in a variety of attractive opaque colors and mottles. Colors go all the way through, providing a permanent finish without painting or lacquering.

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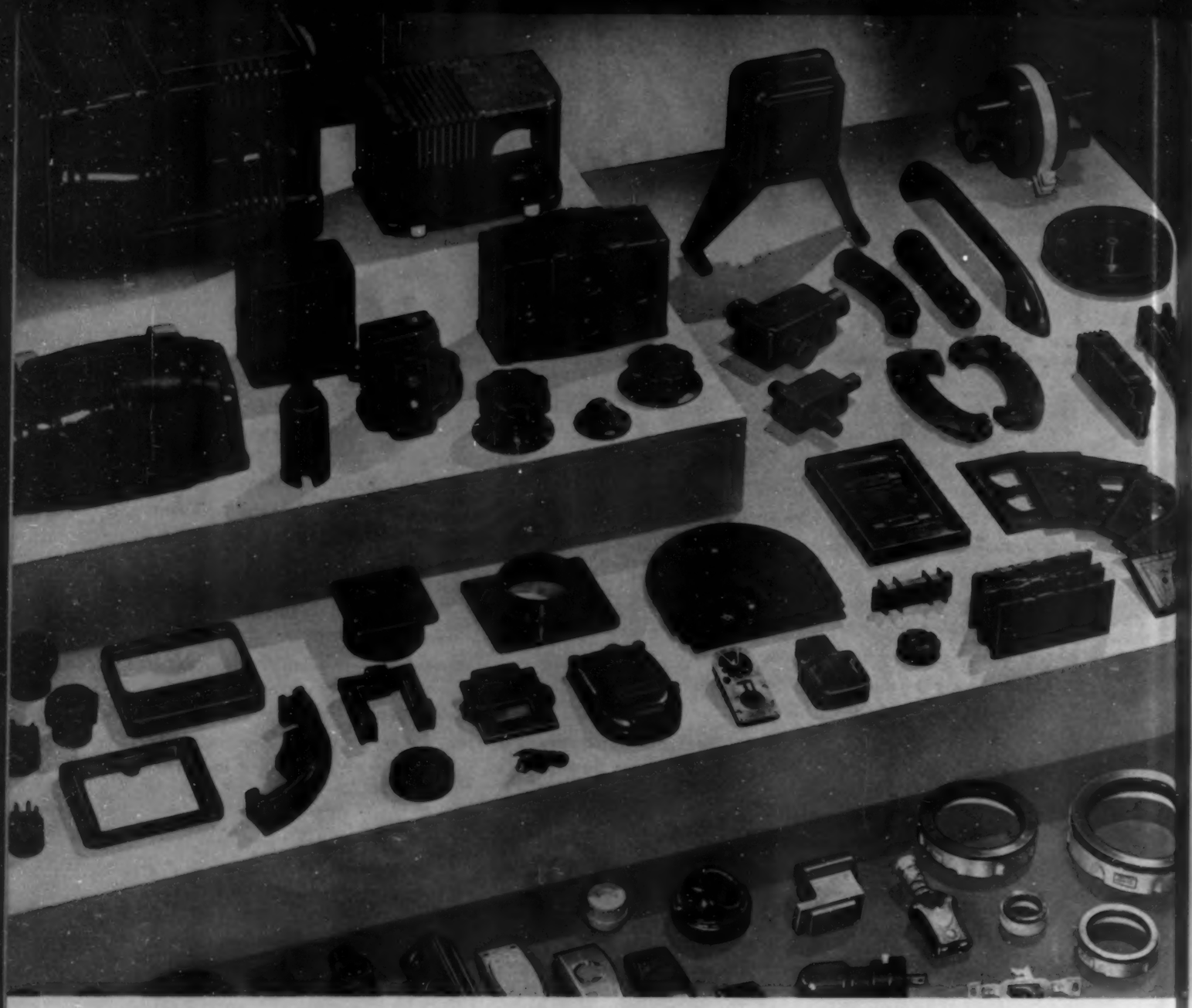

III MANUFACTURE OF RESINOX

Resinox molding materials are based on synthetic resins formed by chemically reacting phenol with formaldehyde. This reaction is accomplished in huge steam-jacketed vacuum kettles, equipped with the most modern temperature and pressure regulating instruments which enable the operator to control the rapidity of the reaction and the characteristics of the resin.

When the reaction has been brought to the proper point, the resin is discharged into big, flat pans where it hardens as it cools. After hardening, it is broken up and ground. At this state, the resin will soften under heat and will dissolve in solvents such as alcohol.

Filler Adds Strength

The phenol-formaldehyde resin next is mixed with a filler—usually wood flour or asbestos—to give it body and strength. Then pigments or dyes are added to give the desired color. Lubricants, to make it mold easily, and hardening agents are added and the mixture is passed between heated rolls to create a homogeneous mass and reduce the bulk.

The material then is ground and screened to uniform particle size.

The molding compound now is placed in moisture-proof containers which are carefully sealed for shipment to the molder. Every step in the manufacture of Resinox molding materials is carefully controlled.

MONSANTO PLASTICS
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IV PRINCIPLES OF MOLDING

The first step in the successful molding of any article is correct mold design. Improper design may lead to a slow rate of production, weakness of the molded piece, a high percentage of rejects and numerous other difficulties. It always is advisable to engage a skilled mold designer who often will be able to reduce production costs and improve the appearance and mechanical strength of a molded article by his practical knowledge.

Basic Mold Design

The basic mold design requirement for simple articles is to avoid undercuts and allow sufficient draft, or taper for easy removal of the molded piece. For more complicated pieces, the mold may be built in sections so that it can be taken apart for removal of the cured article. Mold design should allow for a slight shrinkage factor, usually .007 to .008 inch per inch for wood flour filled Resinox.

Every section of the molded article should be thick enough to give the required strength. On the other hand, unnecessary thickness slows the rate of cure and increases the material cost. To insure even cure, prevent warpage and reduce shrinkage, cross sections should be as uniform in thickness as the necessary design permits.

Rounded corners both on inside and outside surfaces improve flow of the plastic in the mold and give the finished article greater strength. On inside angles, rounded corners reduce the tendency to accumulate dirt and make the article easier to clean. Molds are designed to throw the flash, or excess material, in a direction to facilitate cleaning.

Metal Inlays

To simplify mold construction, designs and letters should be raised rather than sunken. Letters and designs need to be raised very little because the glossy surface of the molded piece brings them out strikingly.

Interesting results may be obtained with metal letters or designs in the form of inlays placed in the mold and which become an integral part of the finished product. These may be used to give individuality to articles produced in stock molds. Metal inserts often are used to simplify assembly operations and to eliminate drilling or machining the molded part.

Since molding temperatures usually range between 320° and 325° F., molds must be channeled so they can be scientifically heated. Some molds, also must be designed so they can be chilled. Carefully selected grades of steel should be used to avoid warpage or distortion under the high pressures employed. It is customary to further harden the mold after machining.

Press Pressures

Presses, varying in size according to plant requirements, develop pressures of from 1,000 to 3,000 pounds, or even more, per square inch of projected area of the molded piece. These pressures are developed from line pressures of from 2,000 to 2,500 pounds per square inch. Additional equipment is required to remove the "fins," or flash, from molded parts and occasionally to polish any rough edges that may remain.

After determining the correct grade of molding material to be used for manufacturing an article, the required amount of Resinox may be placed in the mold loose or as a "pill," made with preforming equipment. Pre-heating the "pills" or granular compounds reduces the molding cycle time.

The mold is closed and heat and pressure applied. For some pieces, pressure is eased off momentarily, just after closing the mold, to permit the escape of entrapped air. The compound becomes plastic and flows to conform to the shape of the mold. Upon continued application of heat and pressure, the phenolic resin plastic mass hardens to an infusible form and may be discharged while still at molding temperature.

Molding is a highly specialized method of manufacturing, yet it is a comparatively simple operation in a well-equipped plant. In addition to proper equipment, molding requires trained, experienced engineers and operators.

V RESINOX MOLDING COMPOUNDS

Resinox molding materials are manufactured to meet specific molding requirements and, therefore, may be placed in several classifications such as: General purpose materials; impact materials, high heat materials, high water-resistant materials, compounds having minimum odor, materials with non-bleeding characteristics, or compounds in wide variety of colors.

Correct Flow Characteristics

For use in plants where only low pressure is available or where molds are necessarily large and intricate, Resinox compounds are manufactured in soft flows. When available pressure is high and molded pieces are small, medium to stiff-flow materials are recommended.

In general, the finish is better when medium or stiff-flowing compounds are used. Medium and stiff-flow molding compounds also tend to shorten the cure and reduce production costs. Wherever possible, the use of extremely soft material should be avoided.

Since there are several hundred Resinox compounds, each of which carries a different specification, we will present representative specifications for each class under "properties of Monsanto Resinox Phenolic Resin Compounds" toward the back of this booklet.

VI HOW TO ORDER

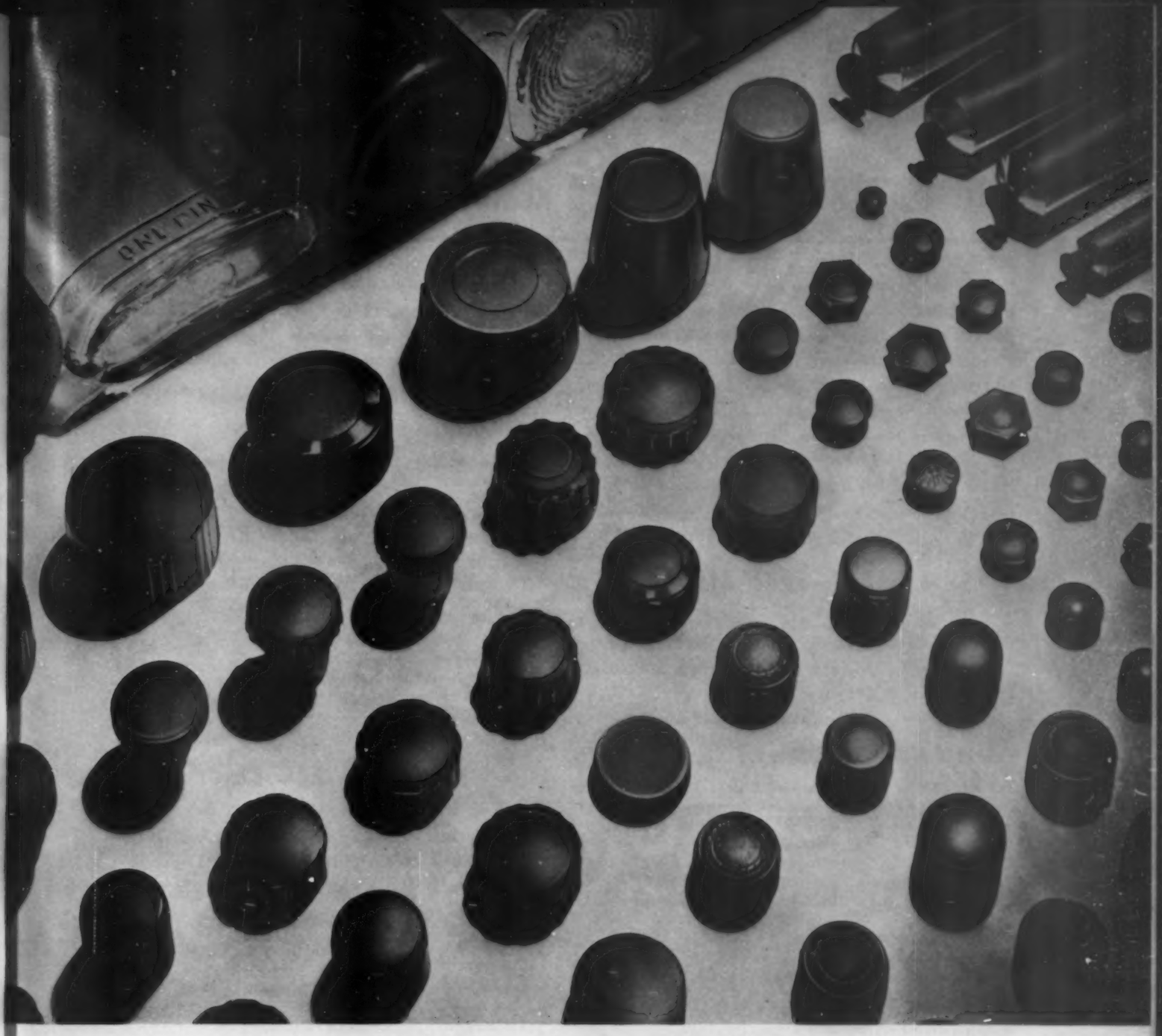
When ordering or requesting samples of Resinox molding compounds, it is important to give sufficient information so that the proper material may be chosen. The flow of the material should be indicated and, whenever possible, a sample of the article to be molded should be furnished together with full information concerning the use to which it is to be put. Information also should be given regarding the importance of surface finish. On new applications of phenolic material, or when it is impossible for the molder to specify the type and character of material needed, the Resinox Technical Service Department will be glad to give assistance.

In ordering colored molding materials, even greater care should be exercised in giving complete information regarding the intended use. Dyestuffs and pigments used in molding compounds are of unlimited variety, and when the use is known, color ingredients may be chosen which will have no undesirable reaction.

VII HOW TO STORE

Resinox molding compounds are packed in welded-seam steel drums. Each drum contains approximately 300 pounds net, except in the case of highly pigmented and high-heat compounds when the net weight will run up to about 450 pounds. The tare weight of drums is approximately 25 pounds.

Drums are sealed with removable tops and rubber gaskets, making them air and watertight. Resinox stores very well in unopened drums but, when exposed in a humid atmosphere, may pick up sufficient moisture to produce a mottling or flow-marking effect. It is, therefore, advisable to replace the lid of



Among the scores of popular applications of Monsanto Resinox Phenolic Compounds are bottle closures. Here the materials add sales appeal with a wide variety of color and serve a useful purpose by providing easy-opening closures. Resinox is available in formulas which resist chemical action of various bottled products while retaining high torque strength to withstand the effect of high-speed capping machines.

the drum whenever it is to stand for an extended period.

Resinox molding compound preferably should be stored at a temperature of approximately 70° F. If it is stored in a cold warehouse and used when cold, it will require a longer curing period since it is necessary for the molding material to absorb more heat to become plastic. Compounds, when used cold, may have a tendency to blister at normal molding cycles.

Care is taken to prevent contamination of molding material before leaving our plant and it is, therefore, important that contamination with other compounds be avoided in the molding shop. This is particularly important with colors in which particles of black or brown material will appear as specks in the finished piece.

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VIII PROPERTIES OF MONSANTO RESINOX PHENOLIC COMPOUNDS

Properties quoted on this and the following pages were determined by A.S.T.M. methods on standard-size test pieces molded under carefully controlled conditions and are, therefore, indicative of the properties of articles molded from these materials. However, such properties are materially affected by the size and shape of the piece and by various molding conditions and, therefore, no guarantee is implied that all articles molded from these compounds will have the properties listed. Electrical properties are not controlled.

RESINOX 3533 BLACK

A GENERAL purpose material recommended for molding articles requiring a smooth, jet-black finish. It is particularly suitable for clock cases, radio cabinets, boxes and similar objects.

(Brown equivalent, Resinox 3533 Brown)

PROPERTIES OF THE MOLDING COMPOUND

Particle Size	Ground to pass U. S. standard 16-mesh screen
Apparent Density	0.52 to 0.60 gram per cc.
Bulk Factor	2.40 to 2.77
Pourability	15 to 20 seconds
Preforming Characteristics	Preforms readily in automatic preforming machine
Flow Range	5 to 10

PROPERTIES, MOLDED

Specific Gravity	1.44
Weight per Cubic Inch	23.6 grams
Flexural Strength	9,200 pounds per square inch
Tensile Strength	6,800 pounds per square inch
Impact Strength	2.50 foot pounds per square inch
Water Absorption	0.63 per cent by weight
Shrinkage	0.0065 to 0.0075 inch per inch

RESINOX 1808 BLACK

A MOLDING material combining good molding properties with very high water and alkali resistance and good mechanical strength. It is recommended for molding parts which are to be subjected to moisture, water or oil and water emulsions. While this material is not as nearly odorless as Resinox 1604 and 3510, extended tests with a variety of cosmetic creams have shown Resinox 1808 Black to be unaffected by, and to have no effect on, such preparations.

(Brown equivalent, Resinox 1808 Brown)

PROPERTIES OF THE MOLDING COMPOUND

Particle Size	Ground to pass U. S. standard 16-mesh screen
Apparent Density	0.54 to 0.64 gram per cc.
Bulk Factor	2.03 to 2.41
Pourability	17 to 24 seconds
Preforming Characteristics	Preforms readily in automatic preforming machine
Flow	8 to 12

PROPERTIES, MOLDED

Specific Gravity	1.30
Weight per Cubic Inch	21.3 grams
Flexural Strength	10,600 pounds per square inch
Maximum Deflection	0.075 inch
Water Absorption	0.18 per cent by weight
Shrinkage	0.009 to 0.0105 inch per inch

RESINOX 1806 BLACK

A GENERAL purpose molding material designed especially for molding pieces with comparatively long draw. The molded parts are characterized by a deep, jet-black color and a smooth, lustrous surface.

PROPERTIES OF THE MOLDING COMPOUND

Particle Size	Ground to pass U. S. standard 16-mesh screen
Apparent Density	0.53 to 0.62 gram per cc.
Bulk Factor	2.16 to 2.53
Pourability	15 to 20 seconds
Preforming Characteristics	Preforms readily in automatic preforming machine
Flow	8 to 16

PROPERTIES, MOLDED

Specific Gravity	1.34
Weight per Cubic Inch	22.0 grams
Flexural Strength	10,200 pounds per square inch
Maximum Deflection	0.056 inch
Tensile Strength	6,700 pounds per square inch
Impact Strength	2.70 foot pounds per square inch
Dielectric Strength at 60 cycles	450 volts per mil
Water Absorption	0.65 per cent by weight
Shrinkage	0.0065 to 0.0075 inch per inch

RESINOX 1602 BLACK

A GENERAL purpose molding material combining rapid cure with high mechanical strength of the molded piece. Resinox 1602 Black is particularly suited for the molding of parts requiring superior flexural strength with medium gloss and finish.

(Brown equivalent, Resinox 1602 Brown)

PROPERTIES OF THE MOLDING COMPOUND

Particle Size	Ground to pass U. S. standard 16-mesh screen
Apparent Density	0.55 to 0.63 gram per cc.
Bulk Factor	2.21 to 2.53
Pourability	15 to 22 seconds
Preforming Characteristics	Preforms readily in automatic preforming machine.
Flow	7 to 16

PROPERTIES, MOLDED

Specific Gravity	1.39
Weight per Cubic Inch	22.8 grams
Flexural Strength	11,000 pounds per square inch
Maximum Deflection	0.060 inch
Tensile Strength	6,500 pounds per square inch
Impact Strength	2.96 foot pounds per square inch
Dielectric Strength at 60 Cycles	450 volts per mil
Water Absorption	0.83 per cent by weight
Shrinkage	0.006 to 0.0075 inch per inch

RESINOX 1604 BLACK

PARTS molded from this compound have exceptionally high torque strength, good finish, and more flexibility than the standard molding materials. Resinox 1604 Black is recommended for molding closures and other shallow-draw pieces where fast cure, flexibility, and odorless and non-bleeding characteristics are required.

(Brown equivalent, Resinox 1604 Brown)

PROPERTIES OF THE MOLDING COMPOUND

Particle Size	Ground to pass U. S. standard 16-mesh screen
Apparent Density	0.50 to 0.61 gram per cc.
Bulk Factor	2.23 to 2.72
Pourability	16 to 23 seconds
Preforming Characteristics	Preforms readily in automatic preforming machine
Flow	7 to 14

PROPERTIES, MOLDED

Specific Gravity	1.36
Weight per Cubic Inch	22.3 grams
Flexural Strength	12,000 pounds per square inch
Maximum Deflection	0.068 inch
Tensile Strength	7,500 pounds per square inch
Impact Strength	3.02 foot pounds per square inch
Dielectric Strength at 60 cycles	400 volts per mil
Water Absorption	0.87 per cent by weight
Shrinkage	0.006 to 0.0075 inch per inch

RESINOX 4410 BLACK

(Tentative Specifications)

A SPLENDID closure material especially adapted for Lauterbach machine operation. Produces molded parts possessing excellent finish and strength.

PROPERTIES OF THE MOLDING COMPOUND

Particle Size	Ground to pass U. S. standard 16-mesh screen
Apparent Density	0.53 to 0.61 gram per cc.
Pourability	15 to 22 seconds
Preforming Characteristics	Preforms readily in automatic preforming machine
Flow	6 to 16

PROPERTIES, MOLDED

Specific Gravity	1.39
Weight per Cubic Inch	22.8 grams
Flexural Strength	11,000 pounds per square inch
Maximum Deflection	0.063 inch
Tensile Strength	7,000 pounds per square inch
Impact Strength	2.45 foot pounds per square inch
Dielectric Strength at 60 cycles	450 volts per mil
Water Absorption	0.66 per cent by weight
Shrinkage	0.007 to 0.008 inch per inch

RESINOX 3941 BLACK

(Tentative Specifications)

A SEMI-IMPACT material of highest quality. With Izod method, notched bar, requires 0.274 foot pounds energy to break. Produces molded parts having excellent finish and strength.

PROPERTIES OF THE MOLDING COMPOUND

Particle Size	Ground to pass U. S. standard 10-mesh screen
Apparent Density	0.39 to 0.44 gram per cc.
Bulk Factor	3.1 to 3.5
Pourability	Pours through standard opening poorly
Preforming Characteristics	May require special feeder on preforming machine
Flow	8 to 15

(Continued on next page)

(Continued from preceding page)

PROPERTIES, MOLDED

Specific Gravity	1.36
Weight per Cubic Inch	22.3 grams
Flexural Strength	11,000 pounds per square inch
Tensile Strength	8,500 pounds per square inch
Impact Strength	5.0 foot pounds per square inch
Dielectric Strength at 60 cycles	350 volts per mil
Water Absorption	0.60 per cent by weight
Shrinkage	0.0048 to 0.0058 inch per inch

RESINOX 3827 BLACK

(Tentative Specifications)

THIS MATERIAL is recommended for applications requiring high heat resistance. Parts molded from Resinox 3827 Black will withstand temperatures up to 475° F. This material is an improvement over, and displaces, Resinox 1629 Black.

PROPERTIES OF THE MOLDING COMPOUND

Particle Size	Ground to pass U. S. standard 10-mesh screen
Apparent Density	0.75 to 0.86 gram per cc.
Bulk Factor	2.14 to 2.45
Pourability	25 to 32 seconds
Preforming Characteristics	Preforms readily in automatic preforming machine
Flow Range	8 to 14

PROPERTIES, MOLDED

Specific Gravity	1.84
Weight per Cubic Inch	30.7 grams
Flexural Strength	8,000 pounds per square inch
Tensile Strength	4,200 pounds per square inch
Impact Strength	1.90 foot pounds per square inch
Water Absorption	0.10 per cent by weight
Shrinkage	0.003 to 0.004 inch per inch

RESINOX 5022 BROWN

(Tentative Specifications)

A GENERAL purpose brown molding compound with splendid flow characteristics. Pieces molded of this material possess good mechanical strength, excellent gloss and finish. Particularly recommended for intricate molding operations. Flow range is unusually wide.

PROPERTIES OF THE MOLDING COMPOUND

Particle Size	Ground to pass U. S. standard 16-mesh screen
Apparent Density	0.52 to 0.59 gram per cc.
Bulk Factor	2.34 to 2.66
Pourability	15 to 20 seconds
Preforming Characteristics	Preforms readily in automatic preforming machine
Flow	10 to 16

PROPERTIES, MOLDED

Specific Gravity	1.38
Weight per Cubic Inch	22.6 grams
Flexural Strength	10,000 pounds per square inch
Tensile Strength	7,000 pounds per square inch
Impact Strength	2.8 foot pounds per square inch
Water Absorption	0.8 per cent by weight
Shrinkage	0.0065 to 0.0075 inch per inch

MONSANTO CHEMICAL COMPANY
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Plastics Division · Springfield, Massachusetts

MONSANTO
CELLULOSE NITRATE

SHEETS • RODS • TUBES

DATALOGUE

MONSANTO CHEMICAL COMPANY · PLASTICS DIVISION
SPRINGFIELD · MASSACHUSETTS

MONSANTO CELLULOSE NITRATE is a cellulose nitrate-camphor composition of the thermoplastic type, supplied in sheets, rods and tubes.

It is difficult to realize, when examining this clear, lustrous material, that it is primarily a vegetable product, originating from cotton.

To produce Monsanto Cellulose Nitrate, however, the cotton passes through a lengthy and involved process, scientifically controlled at every point.

From "Linters" to Cellulose Nitrate

The cotton used in this plastic is called "linters" and is the short fibers not suitable for spinning. The cotton linters are highly purified, washed, dried, fluffed and compressed into bales. These linters then are treated with a mixture of nitric and sulphuric acids and water under laboratory controlled conditions.

When so treated, the cotton is called cellulose nitrate or nitrocellulose. After a further thorough purification process, which insures latent stability in the final plastic, the refined cellulose nitrate is mixed with camphor and alcohol to form the colloidal plastic structure.

Molded into Huge Cakes

Large chromium-plated rolls are then used to knead the plastic, removing much of the alcohol and compacting and homogenizing the texture of the material. By skillful manipulation, the mass is built up into slabs about 1″ thick and about 20″ x 50″ in size. A number of these slabs are laid on top of a steel plate and molded in huge baking presses under heat and pressure. This produces a solid cake from which later are produced sheets, rods and tubes.

A Pioneer Plastic

Monsanto Cellulose Nitrate is one of the oldest of the plastics. It is made in an infinite range of colors from clear crystal and pure white on the one extreme to jet black at the opposite extreme; in solid colors, and in thousands of combinations of mottled, grained and veined effects.

This plastic is supplied in transparents, translucents or opaques. It is also made in a perfect imitation of iridescent pearl, which effect is created as a solid overall, in many kinds of mottles and in an infinite variety of colors.

Sheets are sliced from a large cake of the plastic. Monsanto standard size is 20″ x 50″, thus containing an area of one thousand square inches per sheet which makes it very easy to compute the value of any size piece cut from the sheet. Standard sheets are in gauges from .003″ up to .030″, and from then on to any specified thickness up to ¾″. (Even thicker pieces can be supplied on special demand.)

Lamination May Save Costs

For some types of work, sheets are laminated so that if the more expensive pearl effect is needed, the pearl sheet can be made very thin and lam nated to a lower priced sheet to produce the desired rigidity and thickness. In some instances, to produce an effect on the edge, this lamination may consist of almost any number of sheets in contrasting color to produce a striped surface.

How Rods are Made

Rods are made by two methods, extruded or cut. The extruded rod is usually used for solid colors or for certain graining effects, where the graining can be parallel to the rod.

Cut rods are made when block type mottles are desired in color or pattern effects that cannot be accomplished by extruding. Cut rods are made from a cake through much the same veneering process by which sheets are cut from a cake.

Rods are supplied as they come from the extruder or from the cutting machine, or they can be centerless ground to exact specifications if the use requires that treatment.

Methods of Tube Manufacture

Tubes are made by three principal methods—extrusion, spiral wound or butt weld. The extruded tubing is mostly used for solid colors, or for colors with graining effects where the grain may run parallel to the tube. This tubing can be supplied as it comes from the extruding machine, or it can be supplied stretched and ground to exact specifica-

tions for size, both on inside diameter and outside diameter.

Spiral wound tubing, as its name implies, is made from sheet material, spiral wound and welded by a solvent under pressure. This type of tubing is used where color effects are desired that cannot be produced by the extrusion method.

Likewise butt weld tubing is made from sheets, folded and welded with a solvent under pressure. For all practical purposes both spiral wound and butt weld tubes can be considered seamless as the action of the solvent welds the joints to the full strength of the sheet itself.

Rods and tubes supplied by the extrusion method have a standard length of 60″, but can be supplied in other lengths. Spiral wound and butt weld tubing is generally made in 30″ and 36″ lengths, but also can be supplied, on special specification in other lengths.

Adaptable in Fabrication

Monsanto Cellulose Nitrate is fabricated by cutting, sawing, punching, drilling, drawing, molding, turning, printing, embossing and polishing. In addition, it can be plasticized by immersion in a solution and stretched over other materials to provide whatever finish the manufacturer may desire. One such use is the application of this material over wooden heels on women's shoes. It is also used to cover toilet seats, clothes hampers, certain types of furniture and boxes.

Being a thermoplastic material, softened by the application of heat, Monsanto Cellulose Nitrate can be drawn into an infinite variety of cup and dome shapes, and can be bent into desired form. These operations merely involve heating the material to the desired specified temperature, placing it in a die to draw or bend, as the case may be, and chilling it while in the die under pressure.

Molding Cellulose Nitrate

This material can be molded, in which case pellets of the proper size are laid in a hot die or preheated. and squeezed into the desired shape under pressure of approximately 3,000 pounds per square inch of projected area of molding surface. The dies consist of upper and lower halves in which the proper cavities are provided, and the pellets are placed in these cavities and squeezed into shape and chilled while under pressure. Familiar examples of this technique are typewriter keys or adding machine buttons and dentures as molded by the dental profession.

Printing Operations

For printing, which is a specialized industry, Monsanto Cellulose Nitrate sheets are supplied in a mat finish, and are printed with a special formula ink. The printed sheets are then press polished, which makes the printing permanent and provides a smooth and glossy surface.

This operation consists of placing the printed sheet between highly polished plates and pressing them under heat, then allowing them to chill while under pressure. By this means the polished surface of the plate is reproduced on the cellulose nitrate sheet.

Other Fabrication Facts

Monsanto Cellulose Nitrate can be cemented, as in the case of certain built-up type boxes and spiral and butt weld tubing. This is accomplished by the use of a Monsanto solvent which firmly unites the two surfaces to be cemented. The solvent bites into the two surfaces to be joined and unites them so firmly that the strength of the joint is practically equal to the strength of the original sheet.

The ordinary method of polishing is to use a muslin wheel with a mixture of pumice and water. The piece is then given a high lustre by subsequent operations on other wheels, using rouge. Tool marks are readily polished off by this method.

Another method is to tumble-polish, and by this method certain articles, in shapes that lend themselves to tumble technique, can be given a satisfactory finish. In some cases the tumble-polished pieces are given a final hand polish on a wheel, which, of course, produces a much higher gloss. Dip-polishing in solvents also is used on certain articles.

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PROPERTIES OF MONSANTO CELLULOSE NITRATE

MECHANICAL

Specific Gravity	1.35-1.60
Specific Volume, cubic inches per pound	20.5-17.3
Density, grams c.c.	1.35-1.60
Weight per Cubic Inch, (based on specific gravity of 1.4)	0.0507 lb., or 23.0 grams
Refractive Index N_D	1.46-1.50
Tensile Strength, lbs. per sq. in.	6,000-9,000
Elongation, per cent	4-20
Modulus of Elasticity, lbs. per sq. in. x 10^5	2-4
Impact Strength, Charpy (notched) per inch square	3-12
Brinell Hardness, 10 kg. load	10-20
Shrinkage	0-1.4%
Machining Qualities	Very Good

MOLDING PROPERTIES

Type Plastic	Thermoplastic
Molding Quality	Good
Compression Molding Temperature	185-250° F.
Compression Molding Pressure, lbs. sq. in.	100-500
Preforming	Very Good
Tendency to Cold Flow	Very Slight
Molding Methods Applicable	Extrusion, Swaging, Shearing, Blowing—All Very Good
Extruding Quality	Good

THERMAL PROPERTIES

Burning Rate	Rapid
Thermal Conductivity, 10^{-4} calories per second per sq. cm/1° C. per cm.	3.1-5.1
Specific Heat, calories/1° C./gram	0.34-0.38
Thermal Expansion, 10^{-5} per 1° F.	6.5-8.9
10^{-5} per 1° C.	12.0-16.0
Resistance to Heat, °F. (continuous)	Approximately 140
Softening Point, °F.	160-195 Decomposes at 272° F. in 30 minutes
Effect of Heat, dry	Discolors on continued heating at 212° F.

ELECTRICAL PROPERTIES

Volume Resistivity ohms/cms (50% R. H.)	(2-30) x 10^{10}
Breakdown Voltage, 60 cycles, volts/mil	600-1,200
Dielectric Constant, 60 cycles	6.9-8.8
Dielectric Constant, 10^6 cycles	6.15
Power Factor, 60 cycles	.062-.144
Power Factor, 10^6 cycles	.074-.097

CHEMICAL PROPERTIES—PHYSICAL PROPERTIES

Odor	None or Camphorous
Taste	Tasteless
Effect of Age	Slight Hardening
Effect of Sunlight	Yellows on Long Exposure
Effect of Ultraviolet Light	Yellows and Decomposes on Extended Exposure
Effect of Weak Mineral Acids	Good Resistance
Effect of Strong Acids	Poor Resistance, Decomposes
Effect of Weak Alkalis	Very Slowly Decomposes
Effect of Strong Alkalis	Decomposes
Water Absorption, 24 hours immersion	1.3-2.6%
Effect of Hot Water	Softens, Slight Shrinkage
Effect of Cold Water	None
Moisture Transfer, grams/sq. meter/day/.005"	50-75
Effect on Metal Inserts	None
Solubility: Soluble In—	Alcohols Ketones Esters
Insoluble In—	Aromatic Hydrocarbons Aliphatic Hydrocarbons Mineral Oils Animal Oils Vegetable Oils

Color: Available in an extremely wide variety of transparent, crystal, translucent, pastel and opaque colors, as well as in many mottles, pearls and ornamental configurations.

Forms: Available in sheets, rods, tubes and special shapes.

MONSANTO PLASTICS
PRODUCTS OF MONSANTO CHEMICAL COMPANY
PLASTICS DIVISION • SPRINGFIELD, MASSACHUSETTS

MONSANTO
CAST PHENOLIC RESIN

DATALOGUE

MONSANTO CHEMICAL COMPANY · PLASTICS DIVISION
SPRINGFIELD · MASSACHUSETTS

MONSANTO CAST PHENOLIC RESIN is a cast phenol-formaldehyde synthetic resin. To produce this jewel-like material, phenol and formaldehyde are placed in a large reaction vessel with a suitable catalyst, wherein they react with the elimination of water.

This process is unique in that it produces a resin which is temporarily fusible and may be drawn from the reaction vessel in a liquid state and cast or poured into molds of intricate shape and design. By casting instead of molding most unusual color effects can be obtained. On curing, with the castings subjected to heat, the resin is converted to an infusible, insoluble material.

Wide Range of Colors

It is extremely hard and durable, yet may be machined readily. It is an especially brilliant and attractive plastic with unusual beauty of color and depth of tone. The quality of this Monsanto Plastic is maintained by subjecting each ingredient to rigid laboratory tests before use.

Monsanto Cast Phenolic Resin is non-inflammable. Belonging to the thermosetting group of plastics, it is practically inert and has an exceedingly low rate of moisture absorption. This material is supplied in an infinite range of colors, almost perfectly simulating onyx, marble and similar effects, and is also supplied in all of the solid colors, ranging from crystal to jet black, in either opaque, translucent or transparent effects.

Versatile in Application

The material is extremely versatile in use, its applications extending from such small units as buttons, dice and dominoes up to such products as clock cases, radio cabinets, furniture and store fixture trim. It has even been used for outdoor signs of large area.

"*Cast* phenolic resin" means that it is poured in liquid form into molds of desired shapes, and then hardened in the mold by being placed in specially built and accurately controlled ovens.

The Casting Process

The casting technique involves the use of lead for the molds. The master pattern or "arbor" is made of highly polished, specially selected alloy steel.

This arbor is immersed in pure lead at accurately controlled temperature. A basket of lead forms around the master arbor when it is withdrawn from the lead pot. This is then cooled and the lead replica is removed from the master arbor and becomes the mold in which the resin is cast.

The master arbor is used over and over again, and such arbors have stood up for many thousands of pieces. The lead mold is used only once, but the lead in the mold is refined and used over again after the finished casting has been removed.

Economy in Special Shapes

Monsanto Cast Phenolic Resin is supplied in sheets, rods and tubes as well as in an endless variety of special shapes, cast as closely as possible to the finished form, to provide the greatest economy in finishing the casting. As an illustration of the range of casting sizes possible, pieces have been cast that weigh as little as one fiftieth of a pound, and on special order castings have been made that weigh as much as one hundred pounds.

The material is finished very much the same as wood or brass. It can be sawed, turned, engraved, drilled, tapped, embossed, formed to a certain extent, and takes an unusually high and lasting glossy finish.

Machining Methods

The usual method of cutting is to use a carborundum disc instead of the ordinary circular saw. In the manufacture of certain products such as buttons, the material is sliced or cut with a very thin knife so that there is no waste of material. Cutting with a carborundum disc is done cold and under water to obtain a smooth surface, while slicing is done with the material warm.

Drilling, routing, bevelling, chamfering and similar operations are done with the ordinary machines except that the machines must operate at high speed. Various cutters are used, but essentially the only requirement is that these cutters must be ground with more clearance than would be used for metal.

For turning in a lathe or screw machine, the setup would be essentially the same as that for brass, with the exception that speed must be regulated to the size of the job in order to obtain the smooth cut. Again the tools should be ground with more than usual clearance. It might be noted that the shavings coming from the tools should be more in ribbon form than otherwise.

Steps in Polishing

The unusually high and lasting finish on Monsanto Cast Phenolic Resin is obtained by first smoothing the casting with a light sanding operation, unless it has been otherwise machined. Then a mixture of pumice and water is used to prepare the surface for polish on a muslin wheel. This is usually followed by a rouging operation, using the same type of wheel with a rouging compound, usually furnished in the form of bricks. Following this, a clean cotton flannel wheel is used to bring up the gloss. Small items are inexpensively polished and finished by tumbling in various special compounds.

If properly polished, the material can be kept glossy over infinitely long periods of time by merely cleaning it with a moist cotton or linen cloth which restores the lustre.

Typical Applications

Because of the scope of color effects and the adaptability of Monsanto Cast Phenolic Resin to a wide variety of shapes with remarkably low arbor costs, the material finds its way into an infinite variety of uses.

Only a few such applications are given, yet they illustrate the range of applications: Small buttons for children's wear, and large and fancy buttons and buckles for dress ornaments; dice, dominoes, poker chips and Mah-Jongg tiles; knife handles, table cutlery handles, percolator handles and gear shift knobs; rings, bracelets and all types of costume jewelry; pen bases, book ends and trophy bases; clock cases ranging from very small boudoir clocks to large upright clocks; radio cabinets; boxes of all sorts; indoor, and in some cases outdoor, signs; decorative trim for furniture and store fixtures, cabinets or trim for vending machines and coin-operated machines.

Wherever color helps to sell, Monsanto Cast Phenolic Resin provides the ideal answer with a material whose color is both *brilliant* and *long-lasting*.

MONSANTO PLASTICS
SERVING INDUSTRY . . . WHICH SERVES MANKIND

PROPERTIES OF MONSANTO CAST PHENOLIC RESIN

MECHANICAL

Specific Gravity	1.325-1.335
Specific Volume, cubic inches per pound	20.9-20.0
Density, gms/c.c.	1.33
Weight per Cubic Inch (based on specific gravity)	21.8 grams, or 0.048 pound
Refractive Index N_D	1.65-1.68
Tensile Strength, lbs/sq. in.	6,000-12,000
Elongation	Very Slight
Modulus of Elasticity, lbs/sq. in. x 10^5	5-15
Impact Strength, Izod (notched)	0.1-1.5
Brinell Hardness, 25 kg. load	30-45
Machining Qualities	Excellent
Compression Strength, lbs/sq. in.	26,000-33,000
Shrinkage	0-1%

MOLDING PROPERTIES

Type	Thermosetting, Non-moldable

THERMAL PROPERTIES

Burning Rate	Will Not Support Combustion
Thermal Conductivity, 10^{-4} calories per second per sq. cm/1° C. per cm.	3-5
Specific Heat, calories per °C. per gram	0.3 x 0.4
Thermal Expansion, 10^{-5} per 1 °C.	2.8
10^{-5} per 1 °F.	1.55
Resistance to Heat, °F. (continuous)	160
Effect of Heat, Dry	None
Moist	Whitens
Heat Distortion	Above Normal Temperatures

ELECTRICAL PROPERTIES

Volume Resistivity, ohms/cms (50% R. H.)	10^9-10^{14}
Breakdown Voltage, 60 cycles, volts/mil	300-450
Dielectric Constant, 60 cycles	4.5-7.0
10^6 cycles	5.0-7.0
Power Factor, 60 cycles	.025-.200
10^3 cycles	.005-.08
10^6 cycles	.01-.045

CHEMICAL PROPERTIES — PHYSICAL PROPERTIES

Odor	None
Taste	None
Effect of Age	Hardens Slightly
Effect of Sunlight	Yellows Slightly on Exposure. Some Colored Materials Fade.
Effect of Ultraviolet Light	Yellows Slightly on Exposure. Some Colored Materials Fade.
Effect of Weak Acids	None or Slight
Effect of Strong Acids	Decomposed by Oxidizing Acids. Reducing and Organic Acids Have Less Effect.
Effect of Weak Alkalis	Slight to Marked, Depending on Alkalinity
Effect of Strong Alkalis	Decomposes
Water Absorption, 24 hours immersion	10-.7%
Effect of Hot Water	Softens and Whitens
Effect of Cold Water	None
Effect on Metal Inserts	Inert
Solubility: Insoluble In—	Most Organic Solvents Alcohols Ketones Esters Aromatic Hydrocarbons Aliphatic Hydrocarbons Mineral Oils Animal Oils Vegetable Oils

Color: Available in an extremely wide variety of transparent, crystal, translucent, pastel and opaque colors, as well as in many mottles and ornamental configurations.

Form: Available in sheets, rods, tubes and a very extensive variety of cast shapes and objects.

MONSANTO CHEMICAL COMPANY

PLASTICS DIVISION • SPRINGFIELD, MASSACHUSETTS

DISTRICT OFFICES

NEW YORK	30 ROCKEFELLER PLAZA
CHICAGO	TRIBUNE TOWER
DETROIT	UNION GUARDIAN BUILDING
ST. LOUIS	1700 SOUTH SECOND STREET
LOS ANGELES	605 WEST OLYMPIC BOULEVARD
DAYTON	NICHOLAS ROAD
MONTREAL	378 ST. PAUL STREET, WEST
LONDON	VICTORIA STATION HOUSE

MONSANTO PLASTICS

SERVING INDUSTRY... WHICH SERVES MANKIND

MONSANTO PLASTICS
Cellulose Acetate • Cellulose Nitrate
Cast Phenolic Resin • Vinyl Acetal
Polystyrene • Resinox Phenolic Compounds
Sheets · Rods · Tubes
Molding Compounds · Castings
Vue-Pak Transparent Packaging Materials

MONSANTO PLASTICS

SERVING INDUSTRY . . . WHICH SERVES MANKIND

Ureas, because of their clean sanitary appearance are quite appropriate for condiment sets and dispensers. Those pictured in Fig. 1 are molded of Beetle for Food Dispenser Company

1

UREA RESINS

by WM. H. MACHALE*

UREA RESINS WERE FIRST PRODUCED COMMERcially in this country in 1929. The basic resin is thermosetting or heat-hardening, and one that can be termed truly "synthetic" since its principal constituents may be made from a combination of four gases: Ammonia, Carbon Dioxide, Hydrogen, and Carbon Monoxide.

Chemistry of formation

Urea resins are produced by reacting urea, $CO(NH_2)_2$, with commercial formalin, (an aqueous solution of formaldehyde, H.CHO), under varying conditions of time, temperature and alkalinity or acidity. Water soluble intermediate products have been identified as containing mono-methylol urea ($NH_2.CO.NH.CH_2OH$) and dimethylol urea ($CH_2OH.NH.CO.NH.CH_2OH$). Commercial urea resins are frequently condensed further than the methylol urea stage for the purpose of modifying resin properties such as plasticity, viscosity, etc.

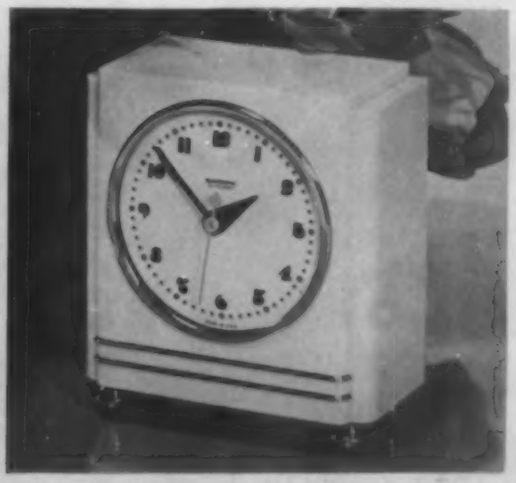
The intermediate resins for many applications are used in admixture with cellulose in some form such as paper, pulp, or rayon fibers before finally curing to an infusible,

* Beetle Products Div., American Cyanamid Co.

Molded housings are standard with many manufacturers who choose urea where light decorative colors are desired. For example; this Emerson radio (Fig. 2) and Hammond clock (Fig. 3) of Beetle

2

3



Plaskon

TYPICAL USES

BOXES . . . . . for Jewelry and Watches

BUTTONS and **BUCKLES**

HOUSINGS . . . . . for Clocks, Radios, Scales and Appliances

CAPS . . . . . for Bottles and Tubes

CONTAINERS . . . . . for Cosmetics

COVERS . . . . . for Boxes and Jars

DIALS, ILLUMINATED for Radios, Automobiles

DOME and **SIDEWALL LENSES**. . . . . for all types of Transportation Vehicles

FITTINGS . . . . . for Refrigerators and Electrical Appliances

HANDLES and **KNOBS** for Radios, Electrical Appliances, Stoves, Cabinets, etc. Kitchen and Bathroom Fixtures, Automobiles

HARDWARE . . . . Permanent Colored Trim

KEYS . . . . . for Organs and Pianos

PACKAGING

REFLECTORS . . . for Lighting Applications

SWITCH PLATES, Receptacles and Other Electrical Wiring Devices

TABLEWARE . . Dishes, Cups, Saucers, etc.

TOYS and **NOVELTIES**

ANY PRODUCT loses or wins on its own merits. In the field of plastics, Plaskon has achieved leadership because of the unique qualities that it possesses. That's why leading manufacturers in many varied lines of business prefer Plaskon to other materials.

Another important contribution to Plaskon's success is the helpful service that Plaskon offers its customers. This includes definite research into any problems involved in new applications. It includes aid in designing new products, as well as assistance in the re-designing of standard items. It includes expert engineering opinion on the methods of manufacturing finished products, as well as experienced counsel on the molding of Plaskon.

Plaskon Experts never cease their endeavor to improve the materials, methods and equip-

. . . world's largest selling

Urea Formaldehyde Plastic

ment that are employed to convert Plaskon into products that possess character, quality and greater sales appeal. For further information and technical data, write to the

PLASKON COMPANY
Incorporated
2121 SYLVAN AVE. TOLEDO, OHIO
Canadian Agent: Canadian Industries, Limited, Montreal, P. Q.

PLASKON
TRADE MARK REGISTERED
MOLDED COLOR

PLASKON FEATURES

1 **PLASKON** may be had in every color imaginable—purest white, dainty pastels, brilliant hues, jet black.

2 **PLASKON** is solid molded color—clean, clear, permanent color. It retains its lustre, will not fade, and its color value is not injured by scratching or abrasion. Plaskon does not, can not, rust, corrode or tarnish.

3 **PLASKON MOLDED COLORS** range from complete opacity to a high degree of translucence. When molded into lighting reflectors, Plaskon provides maximum illumination without glare.

4 **MOLDED PLASKON** is light in weight. Yet it has great strength, is shatterproof, will not chip and resists breakage.

5 **MOLDED PLASKON** is admirably adapted to the requirements of modern designing. It can be molded into almost any shape—from large housings for fixtures and appliances down to the tiniest buttons. Plaskon now is being molded in sizes up to 26" in diameter, 11" deep.

6 **MOLDED PLASKON** is sanitary—odorless, tasteless, inert. The surface is hard, smooth, easy to clean. Nor does it absorb odors or flavors. Molded Plaskon resists the effects of water, oils and organic solvents.

7 **MOLDED PLASKON** has an exceptionally low degree of heat transference and unusually high dielectric strength.

4

5

6

insoluble product. The curing is usually effected by heat in the presence of proper catalysts which are in most instances of an acidic nature or substances which in the presence of the resin tend to become so. The completely cured product is infusible, insoluble and resistant to water and organic solvents.

General characteristics

The unpolymerized urea resins are water clear, water soluble and fusible. As a water soluble resin, this compound is frequently used to treat paper, cloth, and wood veneer for laminating. The resin may be used as the principal bonding material for the laminated sheets or on the surface laminae of sheets where other resins have been used as the principal binder. The surface treatment permits the possibility of surface color without necessitating the use of the resin throughout the lamination. As an impregnator of wood veneer it serves as a binder and protective coating without discoloring the wood.

Another form of the urea resin is used in the manufacture of baking enamels or surface coatings. In combination with alkyd resins the material may be used to provide a hard surface coating resistant to alcohol, grease, and fruit acids and is available in a range of many brilliant colors.

Urea resins are widely used as adhesives in a solution or in combination with some diluent or filler and are set by the hot press method. A cold setting cement for bonding plastics has also found quite a satisfactory use.

Other applications for urea resins in solution are for the treatment of textiles to render them crush-proof, water-repellant, and to alter the finish and to increase general serviceability.

In combination with a finely divided alpha cellulose pulp, the urea resin may be formed into a molding compound, available as a powder or granule. Since the resin is colorless, and the pulp a pale white, the addition of dyes permits accurate color reproduction. This compound is molded at temperatures approximating 285 deg. to 315 deg. F. and at pressures ranging from 3000 to 6000 lbs. to the sq. in. The rate of setting or polymerization depends upon the temperature applied, the curing agents present, and the form of the part. During such treatment the cured part takes on the exact configuration of the die, becomes insoluble and will not soften again under heat. *(Please turn to page 172)*

Plaskon urea handles add to the aristocratic appearance of this Silex coffee maker (Fig. 4) and the same material is used for the molded shade on the Goodlite Co.'s new lamp (Fig. 5). Krauth and Benninghofen have recently introduced a modern sales register (Fig. 6) which is molded of Plaskon by Reynolds Molded Plastics Division

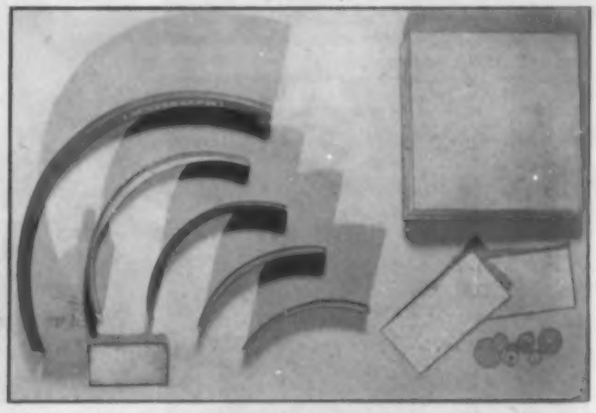
BONDING, IMPREGNATING, INSULATING AND LAMINATING RESINS

Special Durez resins have been developed for adhesives of many kinds. They produce a strong bond with high resistance to oil, soaps, mild acids, and alkalis.

Complete homes are built of "Resnprest" plywood which is Durez bonded because the Durez glue-line is waterproof, and resistant to termites, fungus and mold growth.

Grinding wheels made with Durez resins as a bond can be operated safely at higher speeds, consequently cut faster. Toughness of these resins insures longer wear.

Durez resins impregnate paper and fabrics from which tubing and sheet laminated materials are pressed, serving as both a bond and surface finish. These materials are used for electrical insulation, refrigerator breaker strips, silent gears and many other purposes.



Brake linings impregnated or bonded with Durez resins show longer wear and more uniform coefficient of friction. Composition cork bonded with Durez stands boiling water.

Durez resins are among the most versatile materials in modern industry—with myriad applications.

With Durez resins brake linings hold better and wear longer . . . grinding wheels are bonded . . . cork is bonded for resistance to water and oil . . . armatures, wires, coils and many other electrical parts are insulated. They are used to bond plywood and make it resistant to moisture, vermin, fungus growth.

Durez resins are used in a variety of other applications where heat resistance, electrical insulation, strength of bond, solvent resistance, are vital to the success of the product. Possibly you have a need for some of these resins somewhere in your product or process. There are many types of Durez special resins, each designed for definite applications. Most of them require heat and pressure for application. Our engineering staff and laboratories are always ready to help you choose or develop the one which fits your requirements best. Just write Durez Plastics & Chemicals, Inc., 710 Walck Road, North Tonawanda, N. Y.

DUREZ PLASTICS & CHEMICALS, INC.

PLASTICS THAT FIT THE JOB

Master Ash Tray made by Harry Davies Molding Company, 1428 No. Wells St., Chicago. These beautiful trays are available molded of Makalot Heat Resistant Plastic in Black, Brown, Scarlet, Green, Mahogany or Walnut.

A group of beautiful kitchenware, stove and refrigerator handles, knobs and switches of which hundreds of thousands are molded of MAKALOT by NATIONAL LOCK Co., Rockford, Ill.

HOLLS GAGE, KOPPERS CO. American Hammered Ring Division, Baltimore. Molded of No. 1815 Black MAKALOT by Modern Plastics Corp., Benton Harbor, Mich.

MAKALOT

Independent Producer of

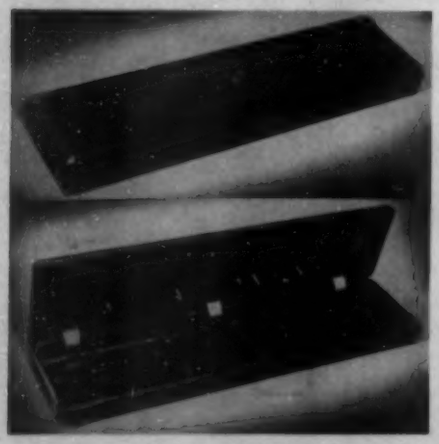
PLASTIC

Molding Compounds

Fabric and Paper Impregnating Resins

Tubes, Rods and Sheets

Phenolic Lacquers, Varnishes, Alkyds



A few of the many styles of handles for stoves, refrigerators and kitchen accessories molded of MAKALOT by the GRIGOLEIT COMPANY, Decatur, Ill.

CHICAGO MOLDED PRODUCTS CO. use MAKALOT No. 2005 Brown in making this wheel because of its beautiful finish and freedom from specks when buffed.

This Presto Dual Salt and Pepper Shaker has a sealed pepper compartment, is easy to use, and is always a salt shaker until pressure is applied across the opposing ribs and then you have a pepper shaker. Molded of MAKALOT by Globe Tool & Molded Products Company, Rockford, Ill.

IMPERIAL MOLDED PRODUCTS CORP., Chicago, Ill., use No. 1215 Black MAKALOT in molding the adjustable photographic film developing tank. Stamp Collectors' Roto-Gage, the unique and useful guide for classifying and evaluating stamps; also stove, percolator, refrigerator handles, name plate frames and various other decorative and useful articles.

Terminal strip for radio frequency use molded of No. 1045 Low Loss MAKALOT by National Company, Malden, Mass., contributes high electrical efficiency and resistance to burning.

National molds this electrical connection plug for radio transmitters and instruments from Low Loss MAKALOT No. 1045.

A push switch for range-changing on radio transmitters. This is one of many National products using Low Loss MAKALOT No. 1045. National coil forms, plug-in mounts, crystal holders and other items show equal benefit from the Low Loss properties of this Makalot material.

It has been quite generally recognized among molders of large, difficult and intricate articles and special materials that (as one large molder stated) "MAKALOT has a faculty of doing things quicker and in most cases better than any of the other Phenolic manufacturers." We have in practically all of our previous advertisements featured some difficult molding where MAKALOT had worked successfully after other materials had failed.

We decided, therefore, for the 1939 October Annual Edition of Modern Plastics to demonstrate by pictures that MAKALOT'S field is not limited to difficult specials but is also excellent for articles where the combined production will run into millions of pieces annually.

We give herein a partial list of our Mid-western customers. Some will vouch the possibility of more cycles per hour using MAKALOT (reports are from 1½ to 6 extra cycles per hour). Some admit better luster, others better casting, less finishing costs, less rejects and other desirable qualities.

American Electrical Heater Co., Detroit.
American Phenolic Corp., Chicago.
Chicago Molded Products Corp., Chicago.
Harry Davies Molding Company, Chicago.
Detroit Molded Products Co., Detroit.
Eclipse Molded Products Co., Milwaukee.
E. & S. Molding & Machine Co., Chicago.
Globe Tool & Molded Products, Rockford, Ill.
The Grigoleit Co., Decatur.
Imperial Molded Products Corp., Chicago.
Midwest Molding & Mfg. Co., Chicago.
Modern Plastics Corp., Benton Harbor, Mich.
National Lock Company, Rockford, Ill.
The Richardson Co., Melrose Park, Ill.
Van Norman Molding Co., Chicago.

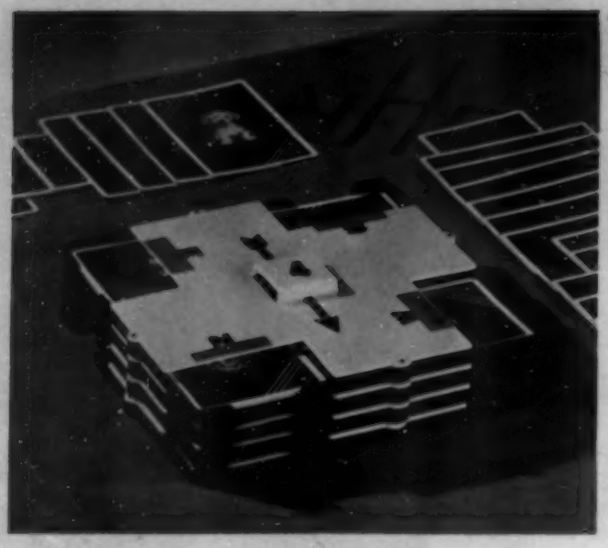
MAKALOT CORPORATION

262 Washington Street

Boston **Mass.**

Factory, Waltham, Mass.
Central States Representative:
C. R. Olson, 2008 6th St., Rockford, Ill.

Manufacturers of Molding and Paper Impregnating Resins, Lacquers Varnishes and Alkyds.



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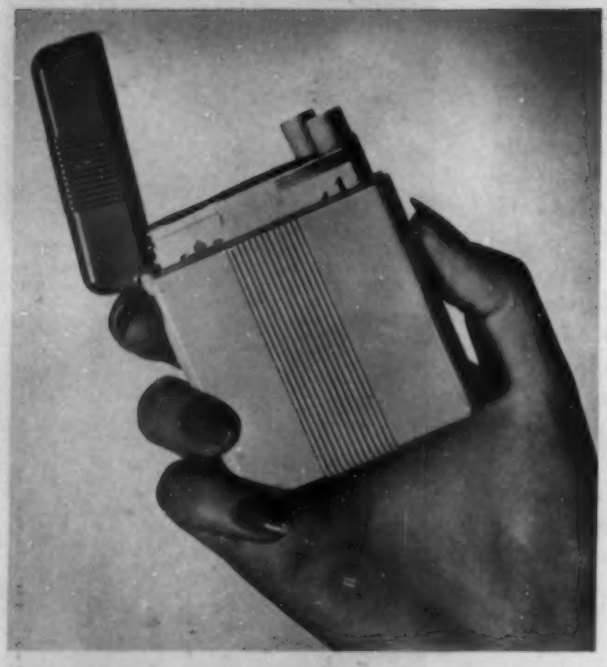

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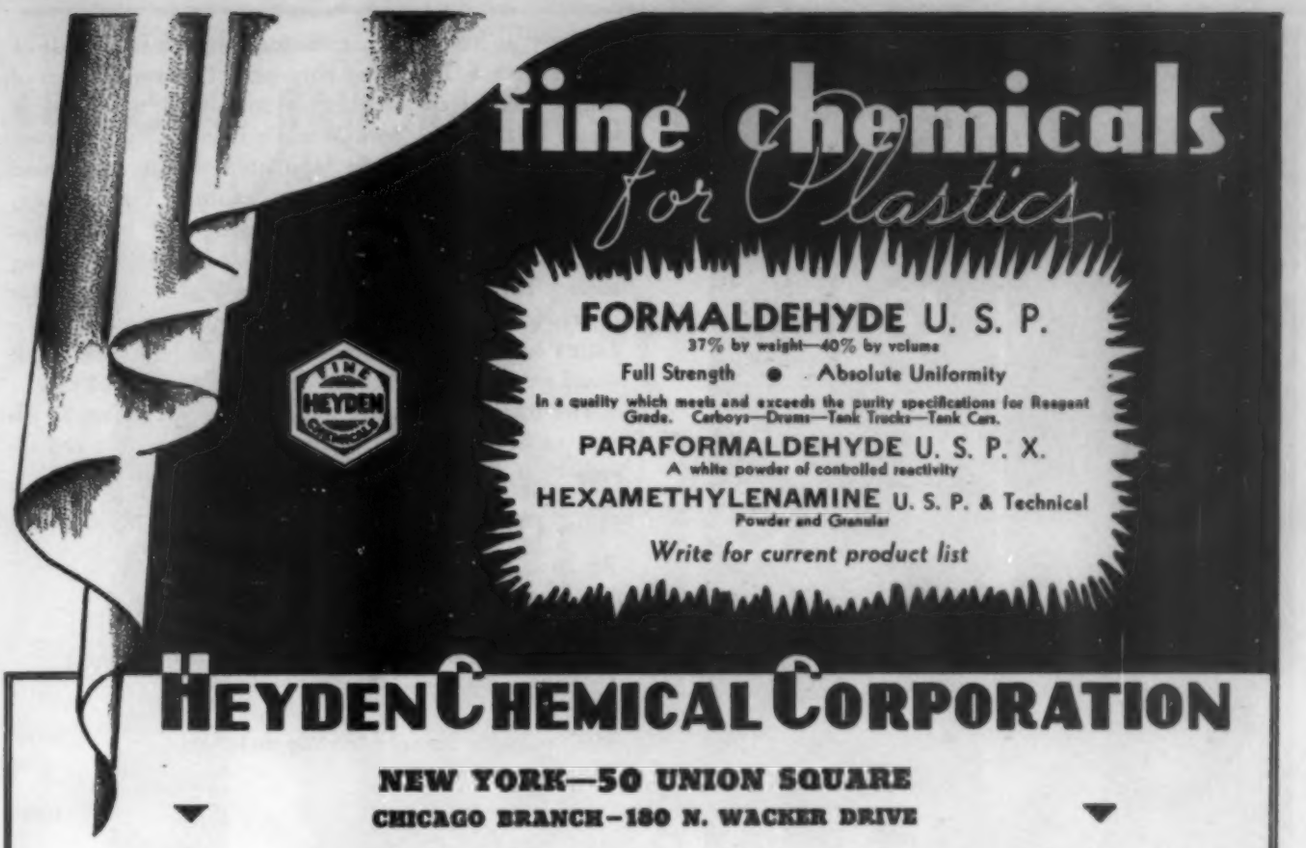
The finished part, whether it be as a molded article or a laminated section, is practically inert—that is, it is odorless, tasteless, and resistant to organic solvents. Its surface is hard and durable. The molded section is rigid, extremely light in weight, and quite strong, but under shock can be broken.

Developments in 1939

The year 1939 has seen an increase in the general knowledge regarding the control of urea molding compounds in production and molding. Assisting this control was the use of an accelerated aging test designed to impose upon a molded part in a short space of time the atmospheric conditions to which it would be subjected over a period of years. By treating molded parts alternately with humid and dry air, it was possible to ascertain at what points structural weaknesses existed in pieces which would result in a breakdown from the swelling and contracting of actual service. Through a correlation of these data from scores of such tests, it was possible to recognize what flow conditions or designs were likely to lead to defective parts. The result has been the development of modified molding compounds which tend to reduce these weaknesses in existing cases, and to assist the designer in avoiding such mistakes in the future. As a result of this increased knowledge of urea molding compounds, general classifications of compounds were designed for general classes of molded parts, depending upon shape, thickness, direction and degree of flow. This has, in general, led to a more satisfactory use of the product.

Another improvement in the process of production is the increased control of color. Color is an outstanding characteristic of the compound, and color matching and control are of primary importance. Control must be exceedingly accurate for such applications as plastic luminaires. This year has seen a rapid growth in the use of ureas for lighting reflectors, illuminated signs, and illuminated housings. This wider acceptance of plastics for lighting is the result of a recognition on the part of the illuminating engineer of the properties this resin has to offer in color reproduction and therefore qualitatively controlled light output. The illuminating engineer can now ascertain quite accurately what light output his proposed bowl will give in quality and quantity, thus saving in mold construction. *(Please turn to next page)*

Bakelite ivory urea tops are combined with black phenolic bases in this duplicate contract bridgeboard set (Fig. 7) molded for F. E. Teal, Ltd., by Universal Molding Co. The new Rathbun Molding Corp. "snapbox" for cigarets (Fig. 8) and the Detrola Pee Wee radio (Fig. 9) are also Bakelite urea. Chicago Molded Products Corp. molded the radio


fine chemicals
for Plastics
FORMALDEHYDE U. S. P.
37% by weight—40% by volume
Full Strength • Absolute Uniformity
In a quality which meets and exceeds the purity specifications for Reagent Grade. Carboys—Drums—Tank Trucks—Tank Cars.
PARAFORMALDEHYDE U. S. P. X.
A white powder of controlled reactivity
HEXAMETHYLENAMINE U. S. P. & Technical
Powder and Granular
Write for current product list
HEYDEN

HEYDEN CHEMICAL CORPORATION

NEW YORK—50 UNION SQUARE
CHICAGO BRANCH—180 N. WACKER DRIVE

Factories: **Garfield, N. J. Fords, N. J.**

MASONITE BENALITE
and
MASONITE BENALOID

Offer unusual opportunities to Industrial Users
requiring flat sheets of
Hard — Strong — Water Resistant Material

Available up to 1″ in thickness

Facts concerning these materials may be obtained
without obligation by addressing inquiries to—

Benaloid Division MASONITE CORPORATION

111 W. Washington St. Chicago, Ill.

10

This year has seen a tremendous growth in the use of urea resins for laminating purposes. Great quantities of this material were used in the form of flat translucent sheets at the New York World's Fair for lighting purposes. This translucent laminated plastic has found applications for Fair lighting, railroad car lighting, illuminated signs, theatre marquees, and road signs. The opaque laminated sections, that is, sections having surface laminates of urea, are being used for refrigerator doors, for furniture, and for store fronts. Several fabricators have perfected a method of molding these laminated sections which indicates a more widespread use.

The textile application of ureas and their uses as adhesives have increased tremendously in volume and diversity of application.

Forms available:

Resins in solution for laminating.
Resin in solution for textile treatment.
Adhesives, a heat-setting solution.
Cold-setting cement (solid and liquid components).
Molding powder or granule.

Typical applications: Molding materials:

Closures	Buttons
Display boxes	Lighting reflectors
Housings	Tableware

Electrical wiring devices

Typical applications: Resins:

Translucent and opaque laminated sections in color.
Adhesives.
Baking enamels in any color.
Textile finishes.

11

Outstanding properties of polymerized resin:

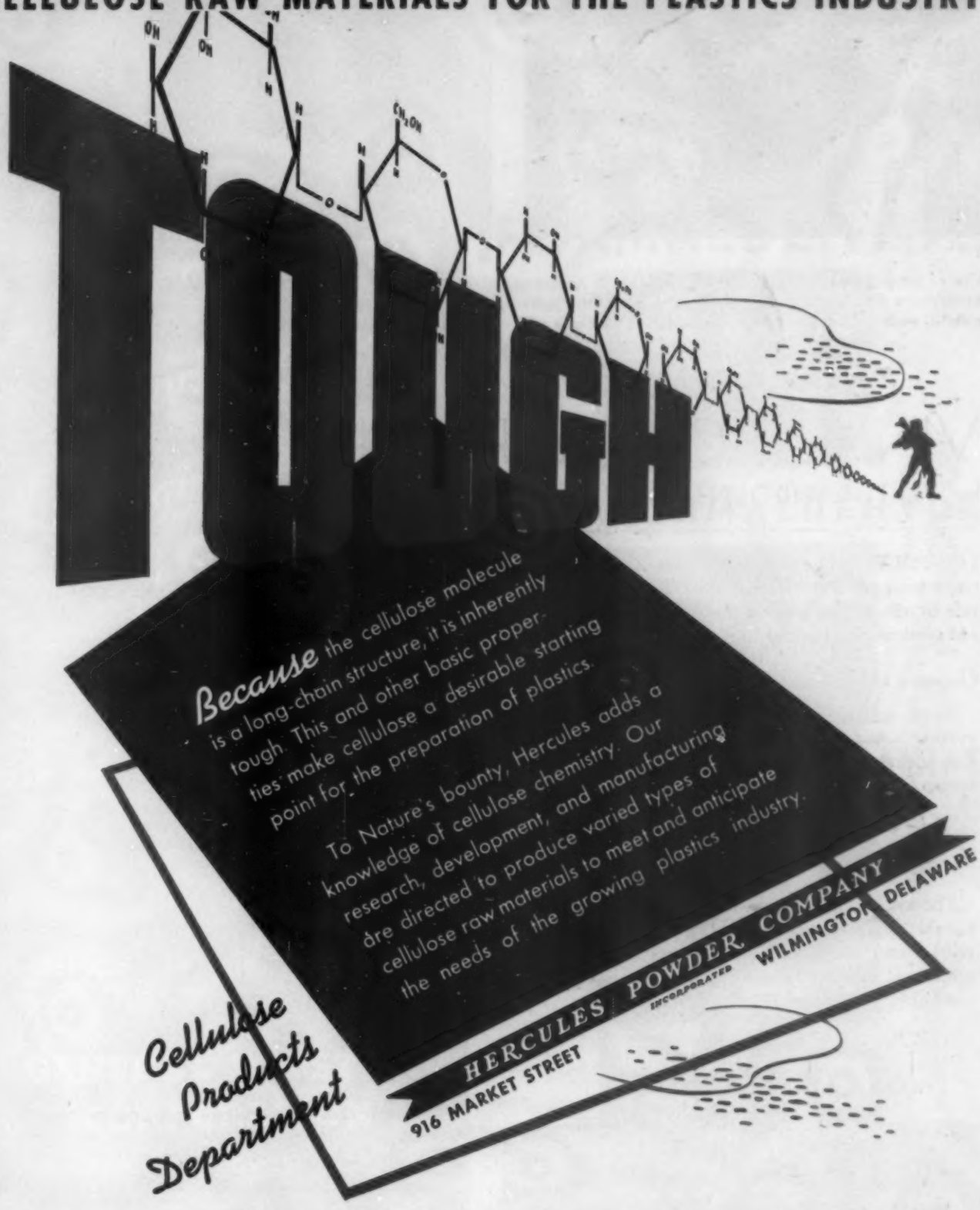
Unlimited translucent or opaque colors.
Odorless and tasteless.
Rigid, shatterproof, hard surface.
Thermosetting.
Excellent light diffuser.
Very lightweight.

Trade names:

Bakelite Urea, Beetle, Plaskon.

Lighting reflectors gain much through the use of urea. They are lightweight, less fragile than opal glass, save breakage in handling, save shipping costs, and wall thicknesses can be definitely controlled to promote maximum efficiency. Mitchell-Vance designed Fig. 10 of Beetle. Mack Molding Co. did the molding. The new small size "Mum" boxes (Fig. 11) have a Beetle base. This material is quite generally used in the cosmetic field

CELLULOSE RAW MATERIALS FOR THE PLASTICS INDUSTRY


TOUGH
Because the cellulose molecule is a long-chain structure, it is inherently tough. This and other basic properties make cellulose a desirable starting point for the preparation of plastics.
To Nature's bounty, Hercules adds a knowledge of cellulose chemistry. Our research, development, and manufacturing are directed to produce varied types of cellulose raw materials to meet and anticipate the needs of the growing plastics industry.
Cellulose Products Department
HERCULES POWDER COMPANY INCORPORATED
916 MARKET STREET
WILMINGTON DELAWARE

HERCULES NITROCELLULOSE • HERCULES CELLULOSE ACETATE • HERCULES ETHYL CELLULOSE

DDD 7

1

2

One of the greatest advancements of this plastic age is represented in the new safety glass with interlayer of vinyl acetal. Fig. 1 demonstrates the "stretchability" of Butacite, a du Pont material, while Fig. 2 shows how shattered glass adheres to similar material, made by Monsanto, so it can be rolled up like a rug. Both materials are used in the manufacture of safety glass

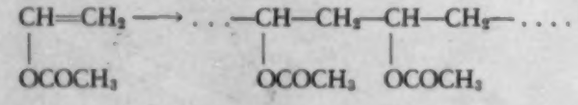
VINYL ACETAL RESINS

by A. F. RANDOLPH*

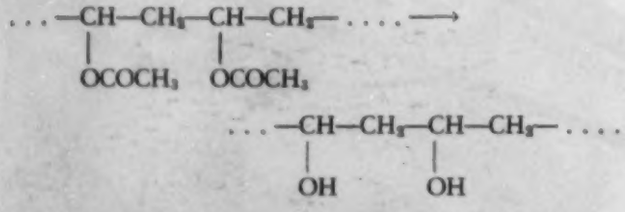
THE POLYVINYL ACETALS ARE A FAMILY OF resins made, on a commercial scale, from polyvinyl acetate by the successive or combined steps of hydrolysis and condensation with aldehydes.

Chemistry of formation

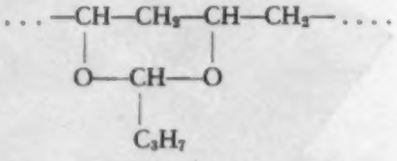
Vinyl acetate, a colorless, mobile and somewhat volatile liquid, is polymerized, usually by the application of heat in the presence of a suitable catalyst, such as benzoyl peroxide, to yield polyvinyl acetate:



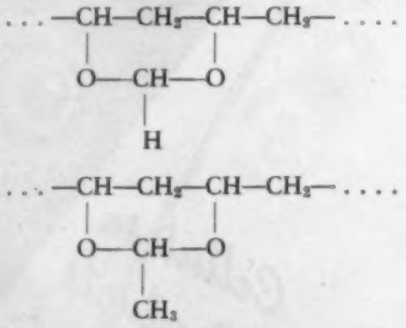
The hydrolysis of polyvinyl acetate, carried out in a suitable liquid vehicle, under the influence of acid or alkali, results in a splitting off of the acetyl groups as acetic acid, leaving hydroxyl groups, to yield polyvinyl alcohol:[1]



Polyvinyl alcohol is now caused to react with an aldehyde, under the influence of heat and a suitable catalyst, such as sulphuric or hydrochloric acid, and one molecule of the aldehyde condenses with a pair of hydroxyls to yield a typical acetal structure. Thus a condensation of polyvinyl alcohol with butyraldehyde results in a polyvinyl butyral:



Analogously, the use of formaldehyde or acetaldehyde results in the corresponding formal or acetal:



The reactions of hydrolysis and condensation may be conducted either as separate operations or together in the same reaction batch.

The resin is finally recovered as a precipitate, which is purified, stabilized and dried.

In commercial production, neither the hydrolysis nor the condensation is carried to completion because it has been found advantageous to have present in the final resin some acetyl and hydroxyl groups, as well as the acetal groups. (*Please turn to page 180*)

* Plastics Dept., E. I. du Pont de Nemours & Co., Inc.
[1] Marvel and Denoon, J. Am. Chem. Soc. 60, 1045 (1938).

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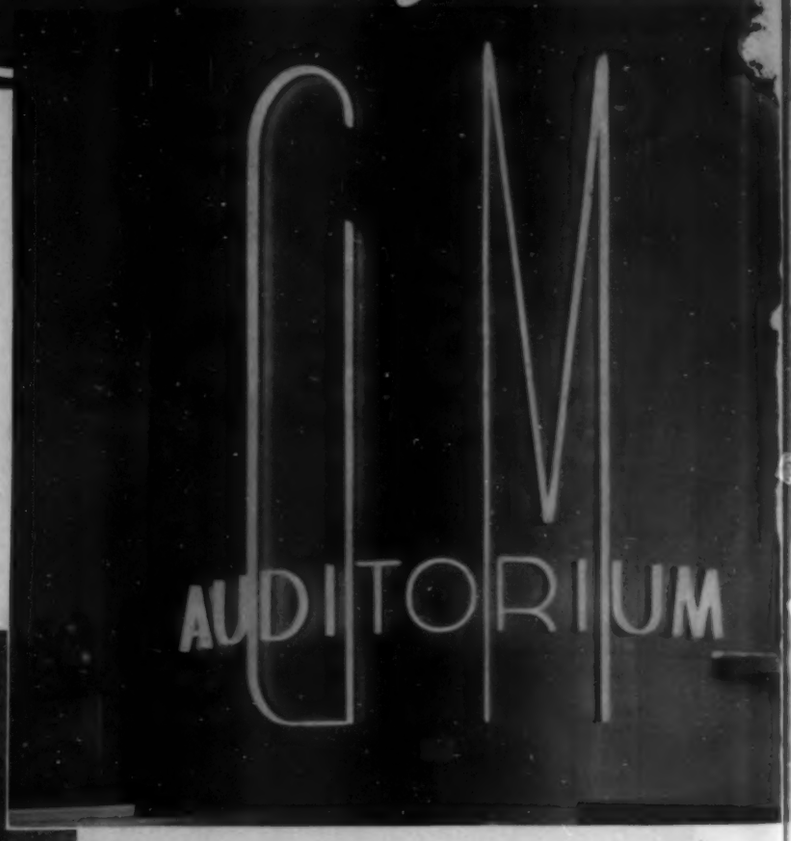
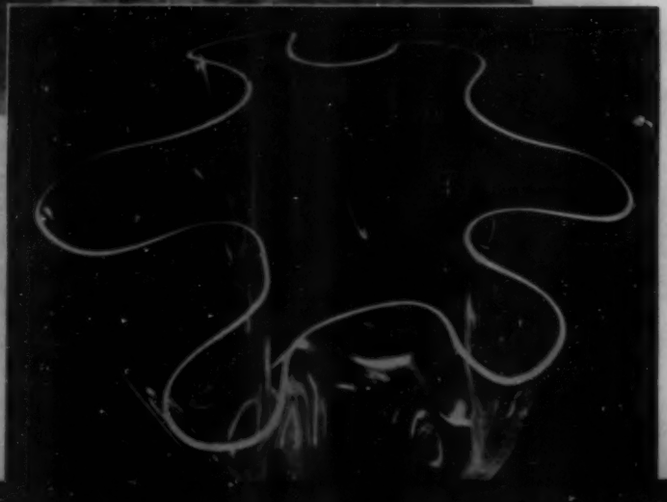
Resistant to Weather

Edge-lighted outdoor sign fabricated of Plexiglas for the General Motors Corporation by the Isbet Electric Sign Service Corporation, New York.



Strong, Hard and Light

Plexiglas, formed to specification, met the rigid requirements set by designers of the Consolidated "Flying Boat".



Shaped to graceful curves simply by heating, Plexiglas was used by Dave Swedlow, Hollywood, California, for this unbreakable salad bowl.

Plexiglas* is available in clear Cry
and colored sheets of a num- ber
ber of sizes and thicknesses pow
and in pieces cut and formed suit
to specification. inje

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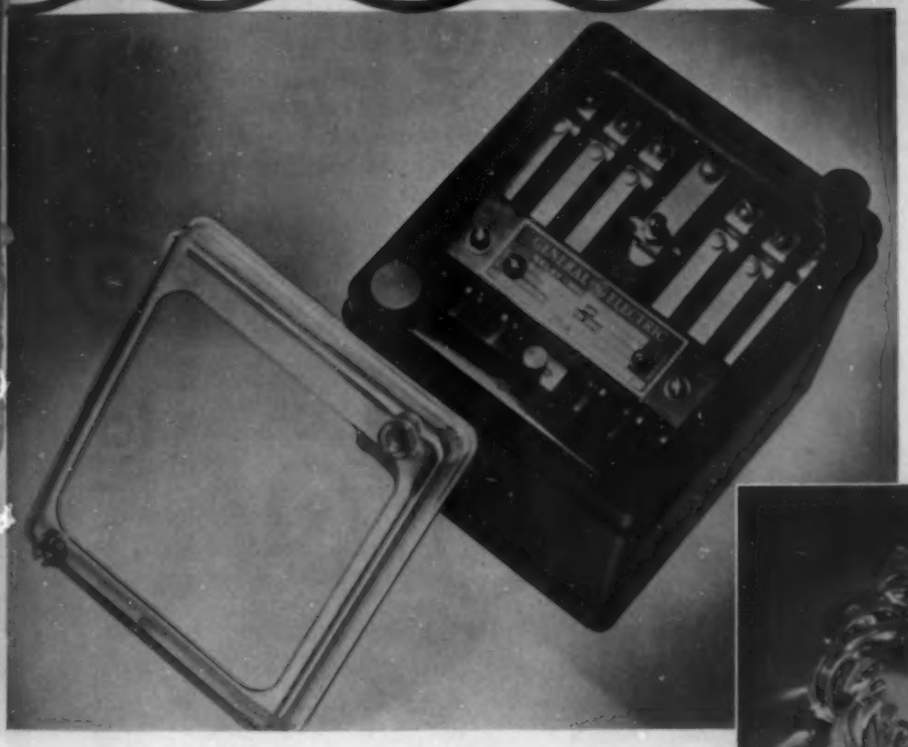
Clear Plastics



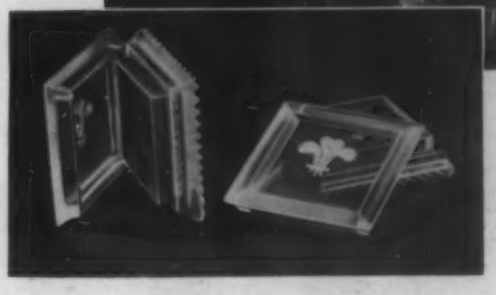
Clearer than Glass

For a permanently transparent cover to its relay box, General Electric's Pittsfield, Mass., plant used Crystalite.

Sparkle like Crystal

Carved like wood, Plexiglas can also be machined, drilled, threaded and polished like any soft metal.

Crystalite* is available in a number of transparent molding powders, colorless and colored, suitable for compression or injection molding.



A brilliant new cosmetic container for Kathleen Mary Quinlan, Inc., New York, molded in Crystalite by The Thomas Mason Company, Inc., Stamford, Conn.

***Trade Mark Reg. U. S. Pat. Off.**

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General characteristics

The properties of a polyvinyl acetal resin are governed by (a) the size of its molecule, which is conveniently expressed in terms of the viscosity of a solution of the resin in standard concentration in a standard solvent at standard temperature, and which is largely a function of the molecular size of the polyvinyl acetate from which it has been made, (b) the choice of the aldehyde used, and (c) the percentages of polyvinyl acetate and of polyvinyl alcohol retained. A knowledge of the effects of these factors on the properties of the resin, e.g., upon its resistance to water, its softening temperature, its compatibility with plasticizers, and its solubility in volatile solvents, makes possible the manufacture of a resin of the desired properties through control of the degree of polymerization effected in the first reaction, the extent of hydrolysis effected in the second, and the degree of completeness of condensation with aldehyde effected in the third reaction.

From among the large variety of possible resins of this family, a few of rather well-defined types have become known as having combinations of properties most suitable for certain specific uses.

In the manufacture of safety glass interlayer, the resin ordinarily used is a polyvinyl butyral containing a very small percentage of polyvinyl acetate and a moderate percentage of polyvinyl alcohol. The optimum type for this purpose has become quite definitely established, and resins which deviate more than a very little from the established standards of viscosity and composition are found unacceptable.

Of the various resins which can be made by condensation with acetaldehyde, several have been found particularly acceptable for molding by compression or by injection. The molding temperatures are in the ranges 100 to 130 deg. C and 170 to 190 deg. C, respectively. Such properties as softening temperature, impact strength and water absorption are influenced by the viscosity and constitution of the resin. These resins, like the butyrals, contain residual acetyl and hydroxyl groups.[2]

Of the resins made by condensation with formaldehyde, one of high formal content has received favorable notice as the basis for an insulating enamel for wire. This resin has a high softening temperature, requires a relatively high temperature for compression molding, and is not suitable for injection molding, but others of this group can be molded by injection.[2]

For uses now in course of development there will be required resins of types different from those now in commercial production.

Jim Mandy, the man with the iron head, unsuccessfully tries to butt his head through a piece of the new Duplate safety glass. (Photo, courtesy Pittsburgh Plate Glass Company)

Developments during 1939

Of chief interest is the considerable extension of the use of vinyl butyral resins in safety glass.

Forms available

Interlayer sheeting of polyvinyl butyral for safety glass, made in continuous lengths and sold in rolls.

Molding compounds.

Methods of fabrication

Manufacture of safety glass: Interlayer sheeting is bonded between sheets of glass by application of heat and pressure, without or with the use of an intermediate adhesive.

Molding by compression and by injection.

Typical applications

Safety glass.

Outstanding properties

The superiority of resins of this class for safety glass interlayer results from their toughness, adhesiveness, insensitivity to moisture, stability toward light and heat, and, in particular, from the fact that, when compounded with certain plasticizers in proper proportion, they are tough and yielding at ordinary temperatures and retain this toughness, as well as their adhesiveness, to an unprecedented degree at both winter and summer temperatures and in humid or dry climates.

Trade names

Alvar (acetal), *Butacite* (butyral), *Butvar* (butyral), *Formvar* (formal), *Vinylite X* (butyral).

[2] Information communicated by Shawinigan Products Corp.

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VINYL ESTER RESINS

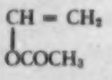
by G. C. MILLER*

THE STEADILY INCREASING POPULARITY AND expanding volume of vinyl resins in diversified industrial applications constitutes ample evidence of the versatility and many desirable properties of this group of resins. Although vinyl polymers have been known for years in the laboratory, it is only within the past few years that several of these resins have been made available to industry at a cost that would permit of their use for any but a comparatively few specialized uses.

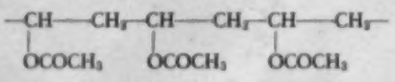
This article does not attempt to cover all resins that include a vinyl radical, but is confined to a brief description of the properties, fabrication and uses of a few such materials that are at the present moment the most important commercially.

Chemistry of their formation

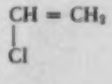
Vinyl acetate is a clear liquid, boiling at 73 deg. C., of the following structure:



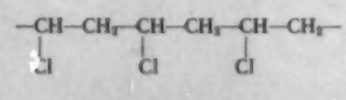
The monomeric material is polymerized to form a linear chain, a portion of which may be shown as follows:



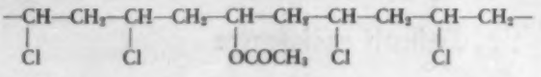
Vinyl chloride is a gas at room temperature and atmospheric pressure, boiling at −14 deg. C., with the following structure:



This monomeric material also polymerizes to form a linear chain:



Vinyl chloride-vinyl acetate copolymer is a result of the polymerization of mixtures of the two materials. Theoretically, under proper conditions of polymerization, the two materials react with themselves and with each other at the double bond to form a conjoint polymer; with a structure as follows:



The vinyl chloride-vinyl acetate ratio may be varied over a wide range in the manufacture of various grades of copolymer resin for specific applications.

General characteristics

Polyvinyl acetate is a thermoplastic, odorless, tasteless, non-toxic, slow-burning, lightweight, colorless material, with reasonably low water absorption. It is soluble in ketones, esters, chlorinated hydrocarbons, aromatic hydrocarbons and alcohol. It is insoluble in water, aliphatic hydrocarbons, fats, and waxes. It is compatible with nitrocellulose and to a lesser degree with shellac, dammar, rosin and ester gum. Where required, "Flexol" plasticizer 3GH and certain of the phthalates, glycollates and phosphates may be used as plasticizers. The resin is produced in a range of viscosities, its plasticity and solubility decreasing as viscosity, or polymer chain length increases. Due to its excellent aging qualities, its lack of odor, taste, or color, and its very good adhesive properties, this resin is widely used as an adhesive in food cartons and drinking cups, and for laminating cellophane and cellulose acetate. Its high gloss and zero acid number make it ideal for metallic lacquers and inks. Mixed with fillers, its low shrinkage makes it well suited for moldings of intricate design and for plastic wood.

Polyvinyl chloride is a thermoplastic resin, odorless, tasteless, non-toxic, non-burning and clear, with excellent chemical resistance and very low water absorption. It is not readily soluble at room temperature,

* Carbide and Carbon Chemicals Corp.

1

2

Eveready dry cell labels (Fig. 1) are protected by an overlay of Vinylite. The blue metal cap is corrosion-proofed with the same material. Shoe lace tips (Fig. 2) molded of Vinylite may be made in any color

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3

4

Long-playing phonograph records (Fig. 3) of Vinylite resin, because of their low noise level, are used for many radio transcriptions. Floor tiles (Fig. 4) in a variety of color effects, are made of Vinylite because they are acid and alkali-proof

but may be dissolved at somewhat higher temperatures in dioxan, mesityl oxide, and chlorinated hydrocarbons. Examples of plasticizers are: tricresyl phosphate, dibutyoxy ethyl phthalate, triglycol dihexoate, and dibutyl phthalate. The resin is incompatible with most other resinous materials, and due to its comparatively high softening point it is plasticized for most uses.

The chemical resistance, freedom from oxidation, low water absorption, good electrical properties, and toughness of polyvinyl chloride have resulted in wide usage of this material for extruded wire coverings, flexible tubings, gasket material, and many other uses that require a material that must not fail under extremely severe corrosive conditions.

Vinyl chloride—vinyl acetate copolymer is a thermoplastic resin of great versatility, combining the best properties of polyvinyl chloride and polyvinyl acetate into a single material. It is odorless, tasteless, non-toxic, non-flammable, non-warping, non-shrinking, tough and has excellent water and chemical resistance and electrical properties. This material is produced in a variety of molecular weights for varied applications, the plasticity and solubility decreasing, and toughness increasing as molecular weight is increased. Solvents are ketones, chlorinated hydrocarbons, esters and polyethers, although ketones are preferable as the active solvent. Coal-tar solvents swell the resin and may be used as diluents. Plasticizers for the copolymer are essentially the same as mentioned above for the vinyl acetate resins. The many excellent properties of this resin are rapidly increasing its use and constantly broadening its field of application.

Developments during 1939

Polyvinyl acetate between latex-impregnated paper and nitrocellulose overcoat in the manufacture of artificial leather prevents any effect of the latex on the nitrocellulose and vice versa.

Used as the adhesive for laminating cellulose acetate to paper, polyvinyl acetate gives the cellulose acetate film greater depth and the appearance of better gloss.

Polyvinyl acetate is the chief component of a new adhesive for securing liner disks to cork backing in crown caps for beverage bottles. It is effective in smaller quantities per unit area than gutta percha and is not subject to deterioration.

A modified polyvinyl acetate is being used for metal lamination in the manufacture of small motors.

Polyvinyl chloride solutions are being used to impregnate fabric for the wrapping of underground pipe lines that are subject to highly corrosive soil conditions. Silk impregnated with solutions of this resin is being used for raincoats, tobacco pouches, and the like. Plasticized material in sheet form is now being used for chemically resistant tank linings, printing blankets, and power transmission belts. The toughness, lack of taste or odor, and high resistance of this material to corrosive agents, water, oil, and grease make it well suited for the above new applications.

Vinyl chloride—vinyl acetate copolymers are now being used in quantity for molding by the injection process, and are supplied in clear and a wide range of colors. The chemical and water resistance, bright mold finish, and non-warping characteristics of this material, are all important factors to the users of molded articles.

Because of its toughness, good electrical properties, and resistance to corrosion or deterioration, plasticized copolymer resin is being used in increasing quantities for extruded cable coatings.

Calendered films of copolymer resin are becoming popular as a thermoplastic adhesive for cloth, and as a laminated coating over printed matter, and as material for direct sound recording.

Sheets of this resin are going into many fields, such as drawing instruments, radio dials, book bindings, cosmetics, and storage batteries, where strength, nonwarpage, non-shrinkage, and chemical resistance are essential in the material used. (*Please turn to next page*)

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Forms available

Polyvinyl acetate—Granular powder and solutions.

Polyvinyl chloride—Granular powder, plasticized sheets, extruded tubes, and special shapes.

Vinyl chloride-vinyl acetate copolymer—Granular powder, calendered film, coated paper, sheets up to 21 1/2 in. × 51 1/2 in. area with polished or matte surface, rods, tubes, special extruded sections.

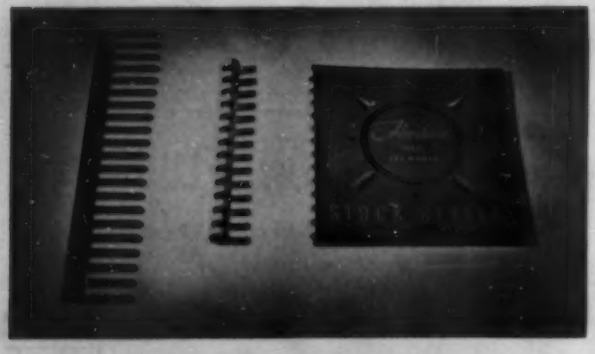
Methods of fabrication

Polyvinyl acetate—For adhesive purposes, this resin may be applied from solution or as hot melt. As a filled molding material it is molded in steel or special alloy molds, with pressures from 1000 to 2000 lbs. per sq. in. and temperatures from 225 deg. F. to 275 deg. F. Castings should be cooled under full pressure to appoximately 90 deg. F.

Polyvinyl chloride—With plasticizer, this resin may be milled, calendered or extruded with standard equipment and conditions used in processing rubber. Standard molds for molding thermoplastics may be used for forming. Pressures and temperatures used will be dependent on the amount of plasticizer, but in general 1000 to 2000 lbs. per sq. in. of casting cross-section area, and temperatures of 225 to 275 deg. F. will be satisfactory.

Vinyl chloride-vinyl acetate copolymer—This resin may be milled, calendered, or extruded with standard rubber processing equipment. Compression molded in steel molds at pressures of 1200 to 2000 lbs. per sq. in. cross-section area of casting, and temperatures of 250 deg. F. to 290 deg. F. Must be cooled under full molding pressure to about 90 deg. F. to 100 deg. F. Is injection molded at 280 deg. F. to 300 deg. F. and pressures of 15,000 to 22,000 lbs. per sq. in. The resin is also applied from solution to metal, paper, or cloth.

Plastic bindings are increasing in general use and Fig. 5 shows 3 steps in the procedure with Vinylite binding. The stamped sheet, the blank shaped to fit, and the binder complete. Cabinet lacquers (Fig. 6) are permanently stainless when made with vinyl ester resins



5

6

Typical applications

Polyvinyl acetate	
Adhesives	Inks
Molding compound (with fillers)	Plastic wood
	Metallic paints
Polyvinyl chloride	Impregnated tape
Cable coverings	Coated fabrics
Extruded tubes	Tank linings
Molded articles	Power transmission belts
Vinyl chloride-vinyl acetate copolymer	Films
Metal coatings	Sheets
Cement coatings	Floor tile
Wallboard coatings	Plastic bindings
Coated paper	Storage batteries
Sound records	Radio parts
Plating tanks	Pen parts
Cable coverings	Combs

Outstanding properties

Polyvinyl acetate	
Clarity	Zero acid number
Adhesiveness	Tasteless
Non-toxic	Odorless
Polyvinyl chloride	
Water resistance	Non-toxic
Chemical resistance	Odorless
Toughness	Tasteless
Vinyl chloride-vinyl acetate copolymer	Water resistance
	Chemical resistance
Non-warping	Non-toxic
Non-shrinking	Colorability
Toughness	Odorless

Trade names

Polyvinyl acetate	*Vinlyite* A *Gelva*
Polyvinyl chloride	*Vinylite* Q
Plasticized polyvinyl chloride	*Koroseal*
Vinyl chloride-vinyl acetate copolymer	*Vinylite* V

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MOLDING AND FABRICATING

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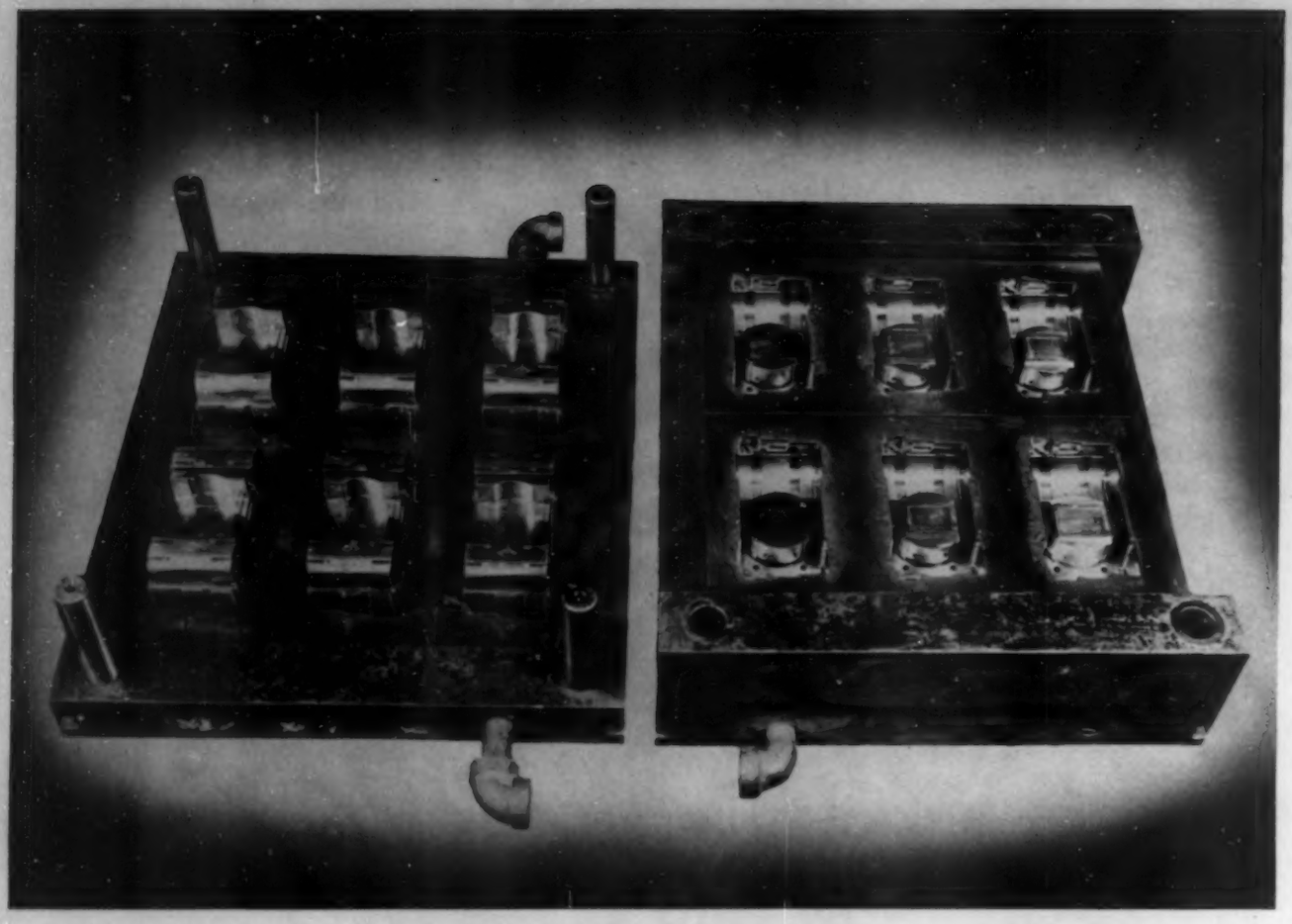


This six cavity mold in operation at Chicago Molded Products Corp., was produced by hobbing the cavities and then machining them to final finished form

METALS FOR MOLDS

by EDWARD F. BACHNER*

GOOD DESIGN IS AN ESSENTIAL FEATURE IN the making of a mold, but is of no greater importance than the selection of the right steels and their proper heat treatments. The first requisite of any steel for plastic molds is cleanliness and the best method of making clean steel is the electric furnace process. Such steels are known as cold melt electric furnace steels and are exceptionally clean and free from internal defects.

Clean steel is insurance against loss of time and money spent in machining a mold only to run into internal dirt or inclusions. Moreover, clean steels lend themselves more readily to the flawless highly polished surfaces so necessary in the plastic molding industry. Highly polished surfaces produce cleaner, better molded parts, cut time and expense in ejecting the piece from the mold and eliminate finishing operations.

* Chicago Molded Products Corp.

First group

Steels for plastic molds can be classified into three groups. The first group is known as Cold Hobbing Steels of which there are two types.

Type A is the low carbon steel, preferred by some users because of its excellent cold hobbing properties. It is furnished to a Brinell hardness of 90 to 100 maximum. It is impossible to secure a very high core hardness in this type of steel but its wear resistance is quite satisfactory when the surface hardness is increased by heat treatment. A typical analysis of these low carbon steels is as follows:

Carbon	*Manganese*	*Phosphorus*	*Sulphur*	*Silicon*
.04	.15	low	low	.10

The treatment of these steels after the cold hobbing operation is the standard carburizing cycle of 1650 deg.

F. for sufficient length of time to obtain the desired case depth, quench in oil from the carburizing temperature and temper at 350 deg. F. for sufficient time to relieve the hardening strains. If it is necessary to anneal between the hobbing operations, the annealing temperature should be 1200 deg. F. to 1250 deg. F.

Type B is the alloy type of cold hobbing steel. These steels are similar to *Type A* except that various alloys have been added to increase toughness and resistance to upsetting. They do not of course lend themselves as readily to cold hobbing as do the low carbon *Type A* steels but are all excellent for simple and shallow hobbing. Those which were developed especially for cold hobbed molds for the plastics industry will give exceptional service even on rather large sections after suitable heat treatment. These *Type B* steels are supplied fully annealed to hardnesses ranging from 120 Brinell to 180 Brinell.

Typical analyses of *Type B* steels are as follows:

Carbon	*Manganese*	*Nickel*	*Chromium*	*Silicon*
.10–.20	.30–.60	1.00–1.50	.45–.75	0.00
.10–.20	.30–.60	3.25–3.75	1.25–1.75	0.00
.10	.45	1.25	.65	.25

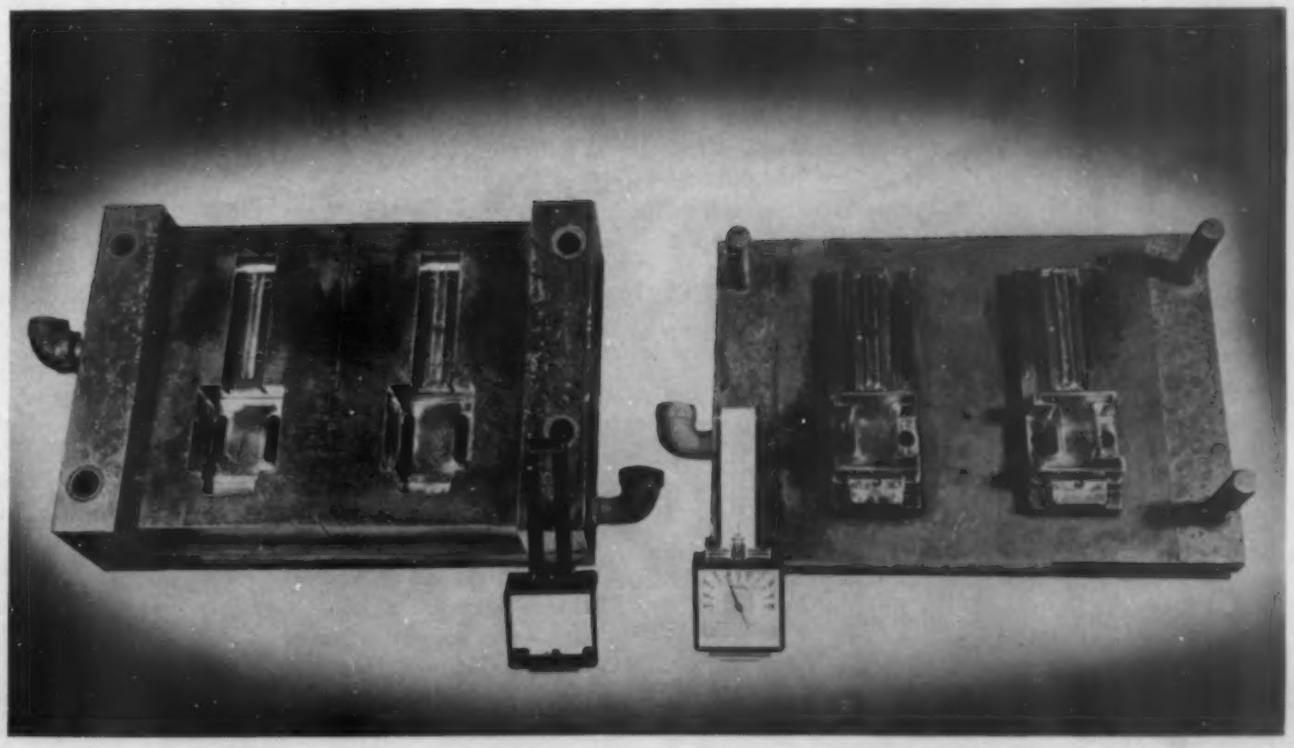
Type B steels must be hardened by some type of carburizing treatment. The carburizing can be done by the use of solid compounds, or gas (natural or artificial), or by liquid compounds. The carburizing is done at a temperature of 1600 deg. F. to 1700 deg. F. for sufficient time to produce the desired depth of case. The case on higher carbon content alloy steels varies from $^{1}/_{32}$ in. to $^{3}/_{32}$ in., depending on the size, cross section and application of the mold. After carburizing, the mold should be allowed to cool slowly and when cold should be reheated to a temperature of 1425 deg. F. to 1475 deg. F. and quenched in oil so that maximum hardness is obtained with minimum distortion.

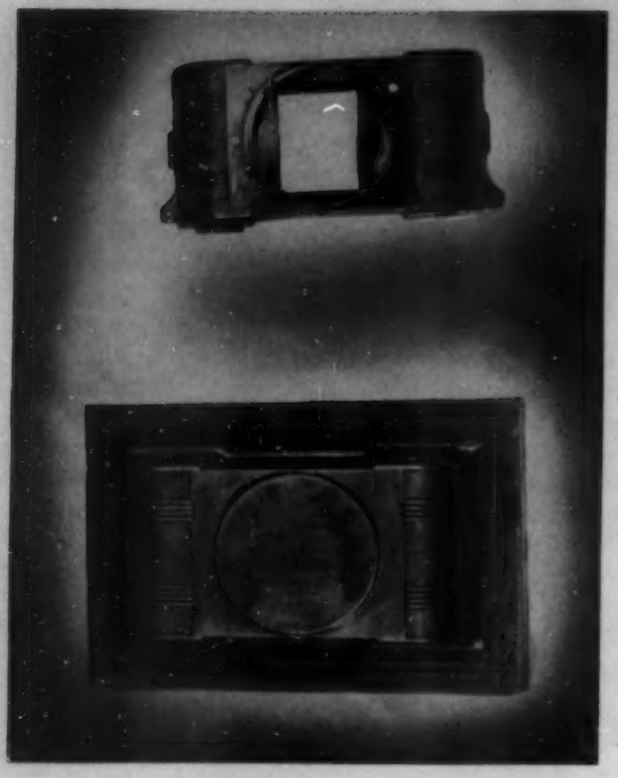
Both the carburizing and reheating processes must be conducted so as to produce a minimum of scale as the mold is polished after heat treatment. There is not so much danger of scaling during the carburizing process as the mold is protected from oxidation by the carburizing gases. The reheating process should be conducted in controlled atmosphere furnaces and the mold should be packed in a container or heated in a molten salt bath so there is no possibility of air coming in contact with the surface of the hot metal.

Quenching should be done by such methods as agitating the quenching medium, flush quenching of the cavity or other proper quenching technique that will eliminate soft spots and minimize any distortion.

After quenching, the mold should be tempered for several hours at temperature of 350 deg. F. to 550 deg. F. Most molds made of these types of materials are used at a hardness of 55 to 60 Rockwell. (*Please turn to next page*)

Cavities and plungers of the die shown below were machined to shape from solid steel blocks. In the center of the photograph, at the left, is one of the molded parts and beside it at right, is the finished product. (Courtesy Chicago Molded Products Corporation)





Chrome tungsten vanadium tool steel, is considered one of the best types for producing hobs. A chunk of steel machined to shape, heated, allowed to cool slowly, then reheated and cooled again, becomes a hard, tough hob requiring only final polishing. Such a hob is shown above together with the plastic molded part. (Courtesy Chicago Molded Products Corporation)

Second group

To the second group belong the steels used for molds not adaptable to the hobbing process—the larger molds which have to be forged and machined to shape. These steels, too, must be clean in structure, free from dirt and inclusions so that after machining costs have been put in, defects will not appear. It is expensive to scrap a partly or nearly finished mold due to defects or dirt inherent in the steel.

In this group are two types of steel. *Type C* is the S.A.E. 3120 chrome nickel steel and *Type D* is the S.A.E. nickel molybdenum steel. Both have been used extensively and are case hardening steels which require a fairly heavy case in order to insure stability of surface. Where large surfaces on the molded parts are to be held to close tolerances these steels do not always lend themselves successfully because of the inability of the core to withstand the pressures used in molding the larger pieces. In addition to this, the necessity of putting on a heavy case and the consequent long period of carburizing heat develops considerable distortion, adding additional expense to the final operation of fitting and polishing the plunger and cavity.

For the past two years we have used considerable cold melt electric steel of medium carbon with a combination of alloys of chrome, silicon, manganese and molybdenum. This type of steel has good machining qualities, changes very little mass shape in heat treatment and can be given a high polish. This steel is supplied at a Brinell hardness slightly under 200 and while somewhat tougher to machine than the lower carbon chrome nickel and nickel molybdenum types we find that with proper heat treatment it gives a very hard case and a high core hardness. Because of its ability to produce a high core hardness it is not necessary to give as heavy a case as required with the lower carbon steels.

It requires a case hardening treatment of 8 to 12 hrs. at 1600 deg. to 1650 deg. F. When the higher temperature is used it should be cooled to 1550 deg. F. and quenched in oil. The draw is usually 400 deg. to 600 deg. F. depending upon the hardness of case desired.

This steel also lends itself satisfactorily to the liquid (cyanide) heat treatment. Where intricate, tricky sections are required in plungers and cavities, this steel can be treated in the following manner: Preheat at 1000 deg. to 1100 deg. F., after the piece has been thoroughly soaked, remove to a cyanide bath at between 1350 deg. to 1400 deg. F., raise temperature gradually to 1550 deg. F. and hold at this temperature for not less than two hours, depending on its size, to assure a good cyanide case. Quench in oil, and the Rockwell "C" hardness will be between 59 and 62, and after a 3 hr. draw at 6500 deg. F. the Rockwell "C" hardness will be 55. This makes a good wearing mold due to the refinement of the core which gives this slight case a strong backing and also resistance to the heavy pressure exerted in the molding process.

Third group

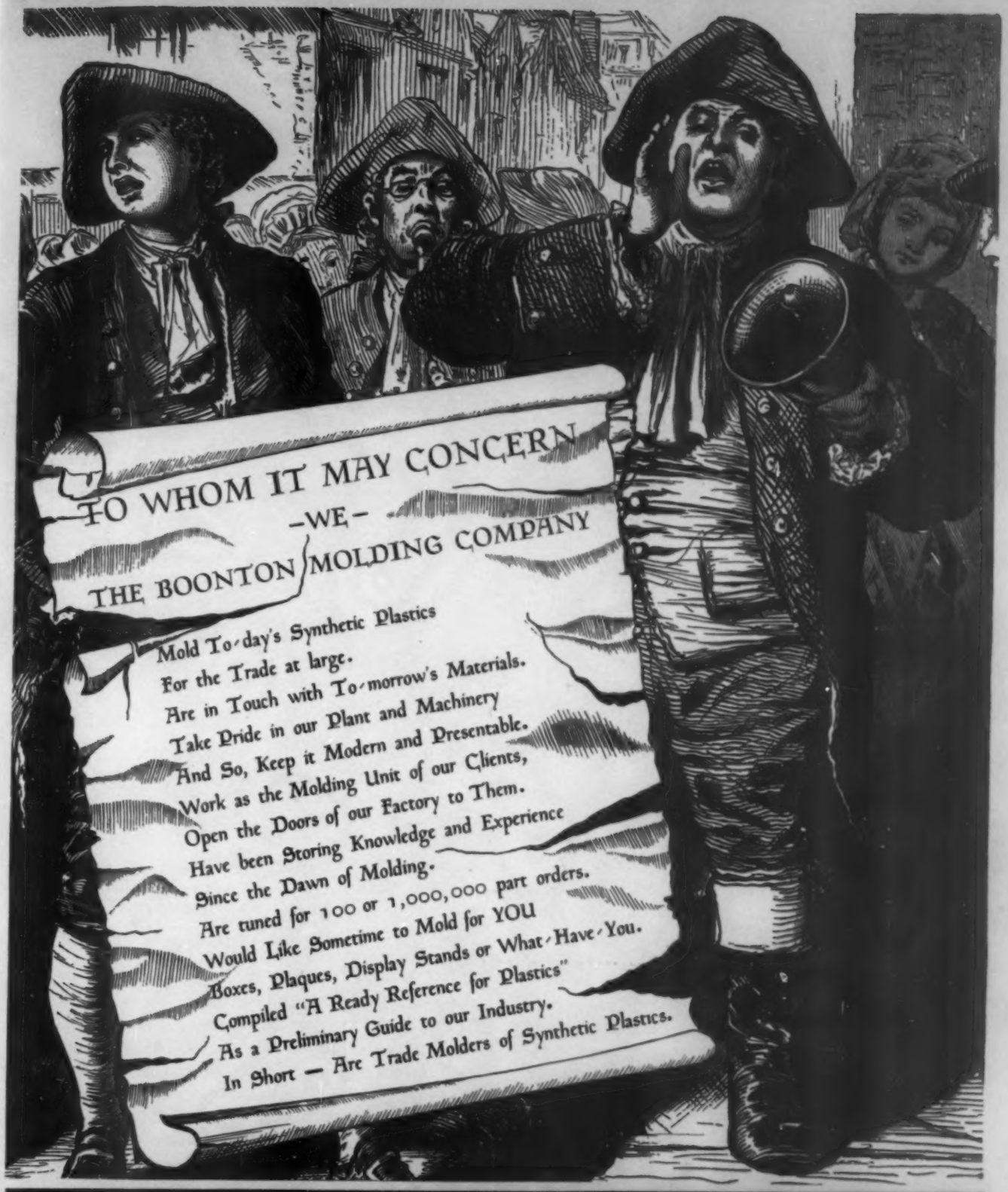
The third group covers the steels most generally used in the making of hobs.

We have found that a chrome tungsten vanadium tool steel is best suited for hobs, a typical analysis of which is as follows:

Carbon	*Chromium*	*Tungsten*	*Vanadium*
.45	1.25	2.75	.25

When the hob has been machined to shape it should be placed in an electric furnace and heated to a temperature of 800 deg. F. This comparatively low temperature distributes the heat uniformly throughout the piece and helps to eliminate possible distortion or cracking. After this preparatory step the temperature is raised to 1600 deg. F. and the hob is then quenched in soluble oil after which it is allowed to cool slowly. This gives the hob hardness but leaves it more or less brittle and so it should be drawn by reheating to 300 deg. F. and then allowed to cool.

This will give a hard, tough hob which requires only careful polishing. For the first polish use fine emery cloth; for the final finish use most any of the various polishing compounds with plenty of hand rubbing.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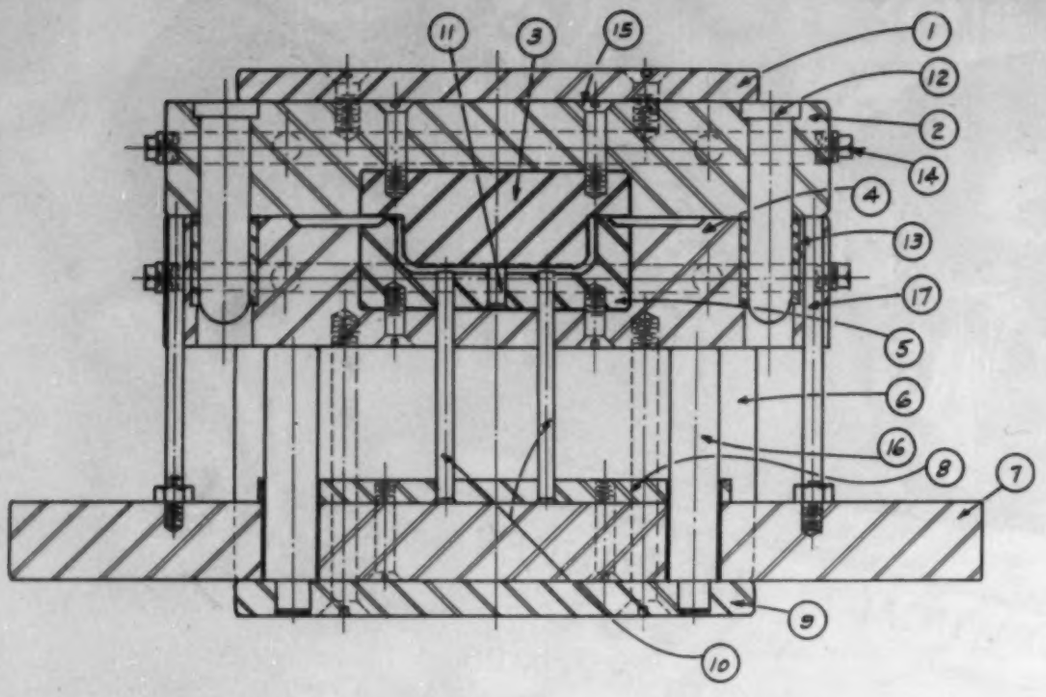

Fig. 1. Flash Mold

DESIGN OF MOLDS

by L. S. GLEASON*

IN THE MANUFACTURE OF PLASTICS IT IS NECessary in most cases to design and build a mold before molded parts can be produced. It is, therefore, of the greatest importance when designing a mold, that most careful consideration be given to all the subsequent manufacturing operations by the mold designer. The difference between a carefully designed mold and a poorly designed mold is often the difference between profit and loss to the producer of the molded parts, or it can mean a satisfied or a dissatisfied customer.

Mold designers should be men with a thorough working knowledge of the methods and equipment used in the manufacture of the molds. They should also have a thorough knowledge of the methods and equipment used in pressing, finishing, and in any other operation which it is necessary to perform to produce a molded part satisfactory to the customer. The mold designer must always realize that it is not enough to just design a mold to produce molded parts, but that these parts must be produced of a quality and at a price satisfactory to the customer. Further, the cost must be low enough to allow the molder a reasonable return on his investment.

There are four general types of molds, known as: flash mold (Fig. 1), landed plunger mold (Fig. 2), loading plate mold (Fig. 3), and straight plunger mold (Fig. 4). A fifth type, known as a sub-cavity type mold (Fig. 5), is not commonly used due to excessive waste of material in the molding operation. These various types of molds may be built as hand molds or semi-automatic molds, according to the production requirements, or to fit into the press equipment of the individual molder who is to manufacture the parts. These mold types may also include wedges, pull pins, threaded pins for internal threads, threaded rings for external threads, spring box arrangement for inserts, stripper plates, and interchangeable sections. Following is a brief description of each of the first four mold types mentioned.

Flash mold.—A flash mold as shown in Fig. I is the simplest type mold to design and build. It consists of a (1) top plate, (2) top retainer steam shoe, (3) plunger, (4) bottom retainer, (5) steam shoe, (6) parallels, (7) knockout bar, (8) pin retainer plate, (9) bottom plate, (10) knockout pins, (11) mold pins, (12) guide pins, (13) guide pin bushings, (14) pipe plugs, (15) screws, (16) support pins, and (17) safety pins. In designing a flash mold, care should be taken to see that the top and bottom plates are thick enough and are fastened securely to the steam retainer plate and parallels to withstand the pull exerted when the press is opened. This pull is caused by the material flowing under pressure up the side walls of the cavity and around the plunger, and solidifying under the heat and pressure. Guide pins and guide

* Plastics Dept., General Electric Co.

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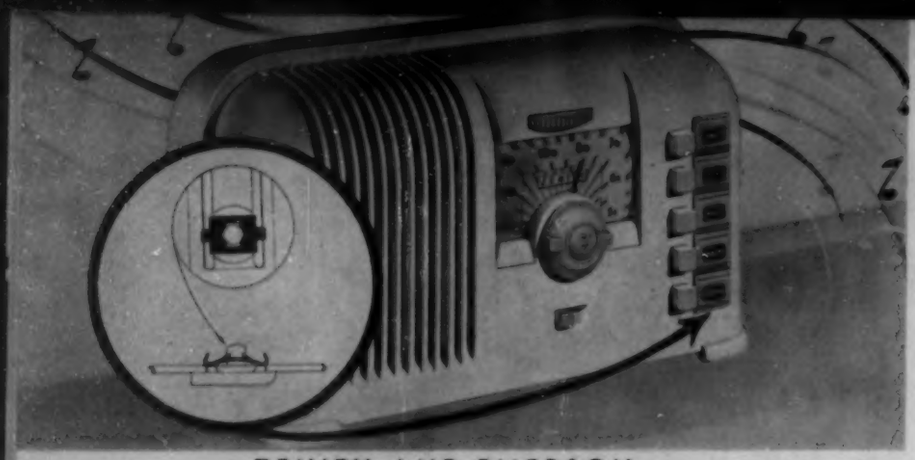

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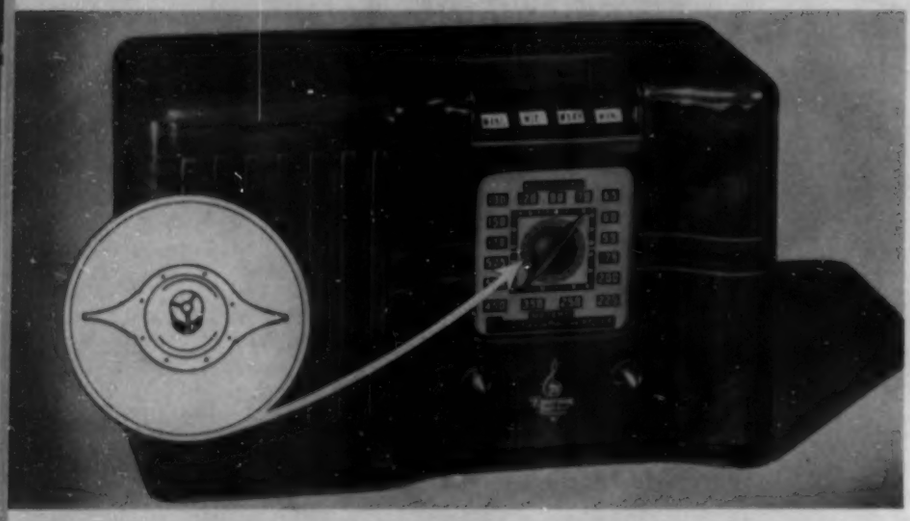

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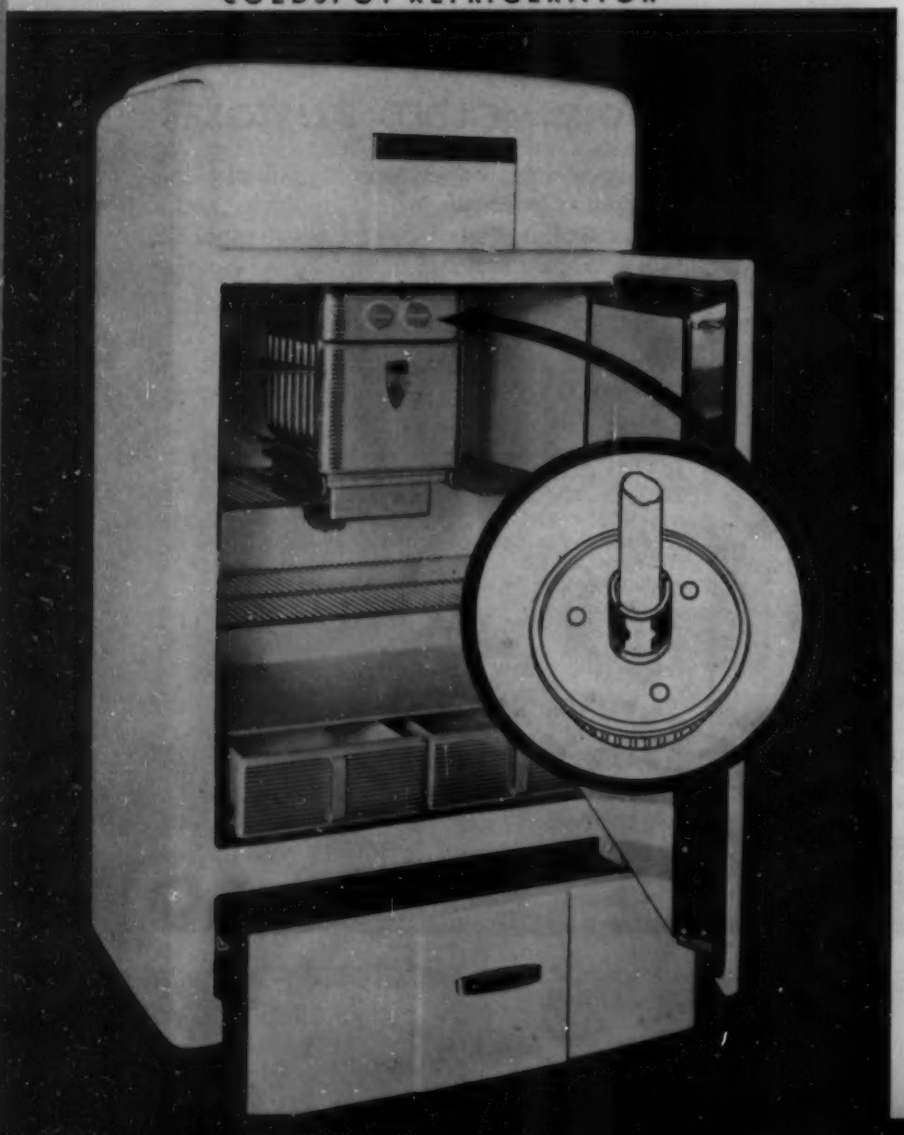

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pin bushings should be fastened securely and ground to tolerances that will allow the minimum of side play and yet allow the top and bottom members of the mold to slide together freely. Recesses for locating the plunger and cavity in the steam retainer shoes should be machined to the same size so that the plunger and cavity may be ground together, assuring as good a line-up as possible when the mold is assembled. Support pads should be placed on the bottom steam retainer shoe, at the same height as the top of the cavity. Thus, when the mold is closed, the pressure will be distributed over a greater area than the cut-off area of the cavity itself. The designer should carefully check the spread between parallels, and if it is too great to withstand the molding pressure, suitable support should be provided under the bottom steam retainer shoe, either in the form of support pins or parallels. These extra supports, should be designed to withstand the pressure of molding; also, the knockout bar should be checked to see that these extra openings through it have not weakened it, permitting it to bend under the ejecting pressure. Knockout pins should be fastened to the bar by means of a pin retainer plate. The holes through this pin retainer plate should be larger than the body diameter of the knockout pins to allow the pins to move as the steam retainer shoe expands under heat. Steam lines should be placed around the cavity and plunger and also beneath them wherever possible. If it is necessary for mold pins to enter the plunger in order to keep them straight, due to their small diameter, or to maintain them at right angles to the bottom of the cavity, a clean-out slot should be placed between the top plate and top retainer steam shoe. It must be of sufficient depth and width to allow easy cleaning of any excess material which may be pushed up ahead of the pin in the molding operation. All sections of the mold should be securely fastened together with screws of a size that will withstand the continual pressure applied in closing and opening the mold.

Landed plunger mold.—A landed plunger mold (Fig. 2) is designed the same as a flash mold with the exception that the cut-off of the material takes place at a predetermined distance below the top of the cavity. This allows for better line-up between the plunger and cavity, which is extremely necessary where thin walls are to be molded. Due to the plunger entering the cavity outside the cutoff, and consequently locking the material in the cavity, it is frequently necessary to provide space for excess material to flow up the sides of the plunger in order that the mold may close and produce a molded part within the required dimensions. The designer should anticipate this condition whenever possible, but if in doubt, this relief should not be specified, but will be determined at the time the mold is sampled. If too much relief is put on the mold, an excess amount of material will be used in making parts, and also it may increase the difficulties in making satisfactory parts.

Loading plate mold.—The design of a loading plate mold (Fig. 3) is the same as that of a flash mold, with the exception that a loading plate is placed on top of the cavity and bottom steam retainer shoe. The object of this loading plate is to provide extra space for loading material to be molded without having to cut this extra depth in the cavity, and also to allow shorter knockout pins to be used, as the loading plate is designed to be carried on the top half of the mold as the press is opened. This is done by letting the loading plate ride on guide pins fastened in the top member of the mold. They must be long enough to pass through the loading plate and

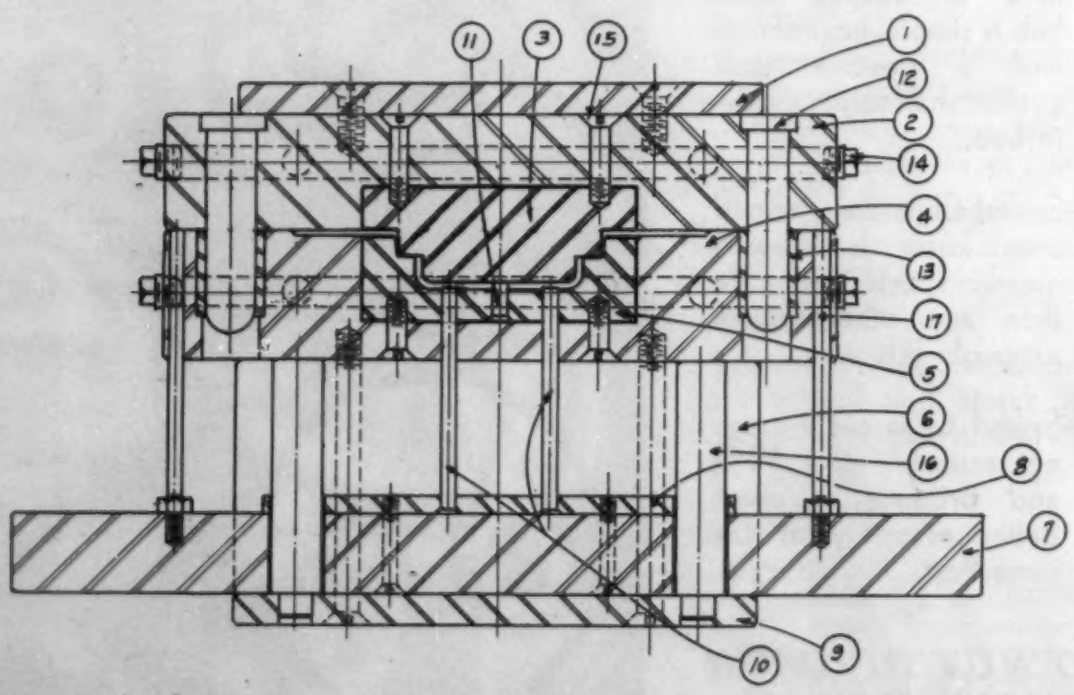

Fig. 2. Landed Plunger Mold

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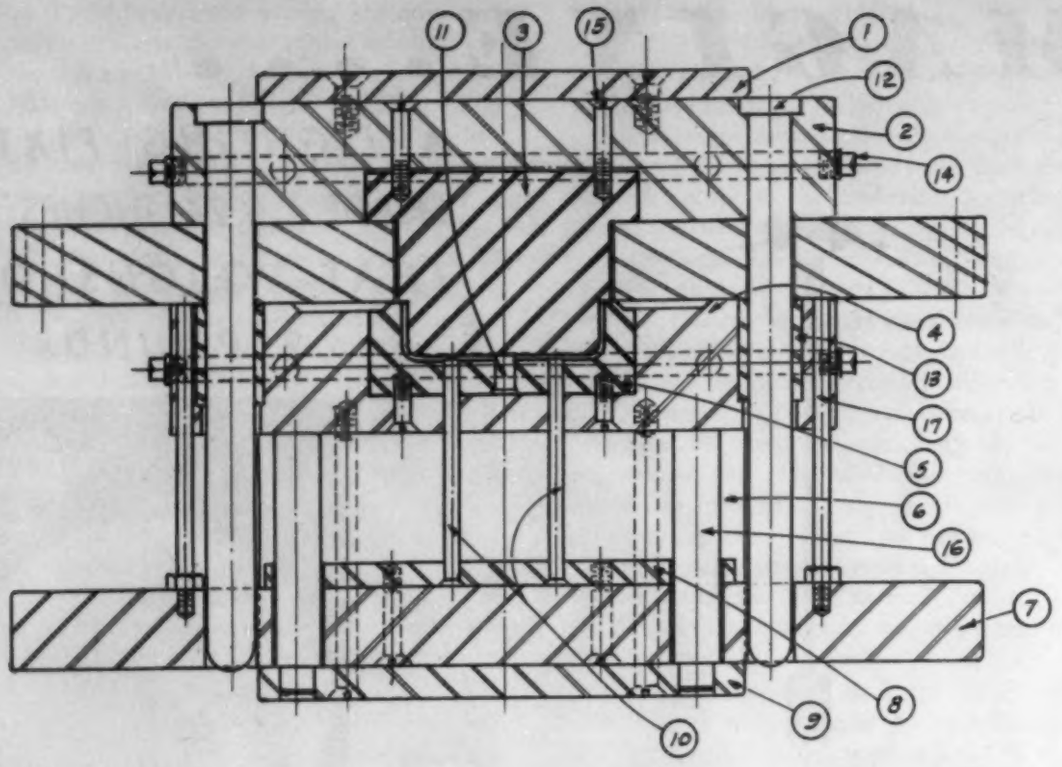


Fig. 3. Loading Plate Mold

enter the bottom half of the mold before the loading plate comes into contact with the bottom steam retainer shoe. The loading plate should be of sufficient length to allow rods to be attached to each end for the purpose of pushing down, and this downward movement is stopped by shoulder screws fastened into the top member of the mold. When a loading plate mold is completely open, the designer should have allowed sufficient space for the operator to work between the bottom of the plunger and the top of the loading plate.

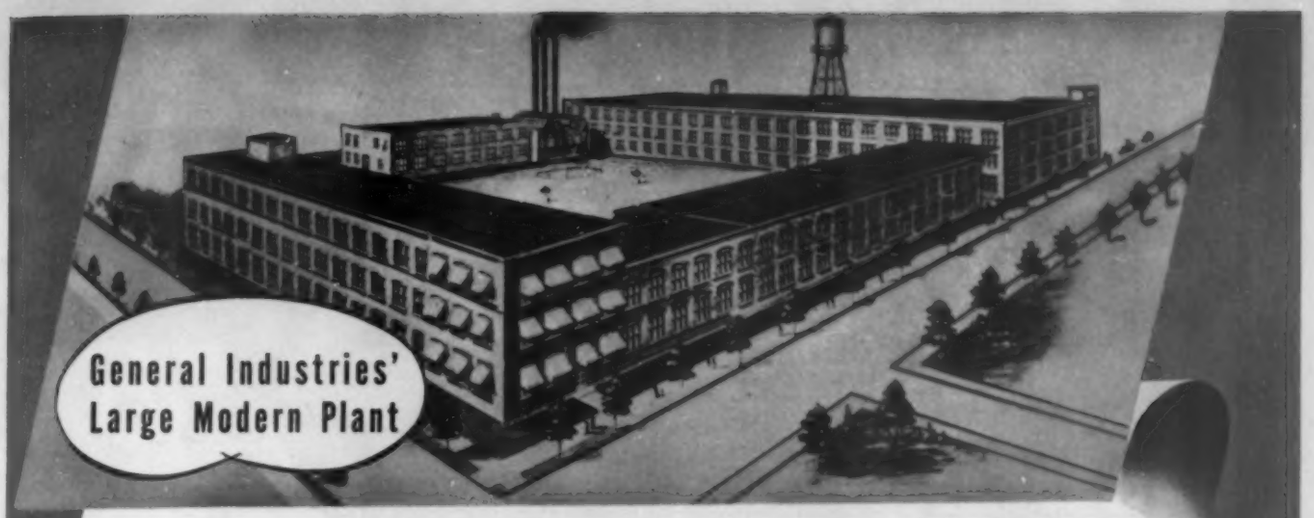
Straight plunger molds.—Straight plunger molds (Fig. 4) differ from flash molds only in that the plunger enters the cavity to a pre-determined depth, completely filling the cavity opening so that when full pressure is on, the molded material is taking the full load of the press. This type of mold makes it very difficult to mold parts within close overall tolerances but does give a part of greater density than any of the other types.

Two-ram or angle-press molds.—Two-ram press molds are either landed plunger or straight plunger in design, with the addition of a moving member fastened to a ram that moves at right angles with the top ram of the press. The main point to keep in mind in designing a mold for the two-ram press is to make the supporting members holding the cavities and plungers sufficiently strong, and to provide interlocks so that when the side ram is closed, the bottom plunger and two side parts are locked into an immovable unit. This is extremely important. From the time the side ram is closed the mold becomes, in action, the same as a landed plunger or straight plunger mold. However, there is another difference and that is in the knockout arrangement. This is usually accomplished by removing a sliding tray with the molded part on it after the mold is opened. The molded part is then removed from the tray by other mechanical means outside the press. When a sliding tray is not required, the bottom member slides away from the cavity walls in the direction of the side ram until stopped in the unloading position by means of stop screws. The molded part is then removed by means of a hand ejector.

Injection molds.—Molds for materials that are used in the machines for injection molding require a different design technique than molds that use materials of the compression type. The mold must be designed to go into a rather limited space, since the strain rods on the machines are fairly close together. Extremely high pressures are developed in these machines and ruggedness of construction with maximum support must be kept constantly in mind. The location of sprues, size and location of gates, must also be given careful consideration. Where movable side members, slides, and cores are used, maximum support and method of controlling movements should be thoroughly gone into by the designer. It is also of considerable advantage, where line-up is important, to use interlocks, and these should be, whenever possible, an integral part of the mold.

In the design of a mold of any of the types mentioned, the designer should take into consideration the following items:

Number of cavities; Size of press required; Type of material to be used; Whether loading into the mold will be in preforms or bulk; Loading space required; What the shrinkage allowance is for the particular material used; Where to put the guide pins and how



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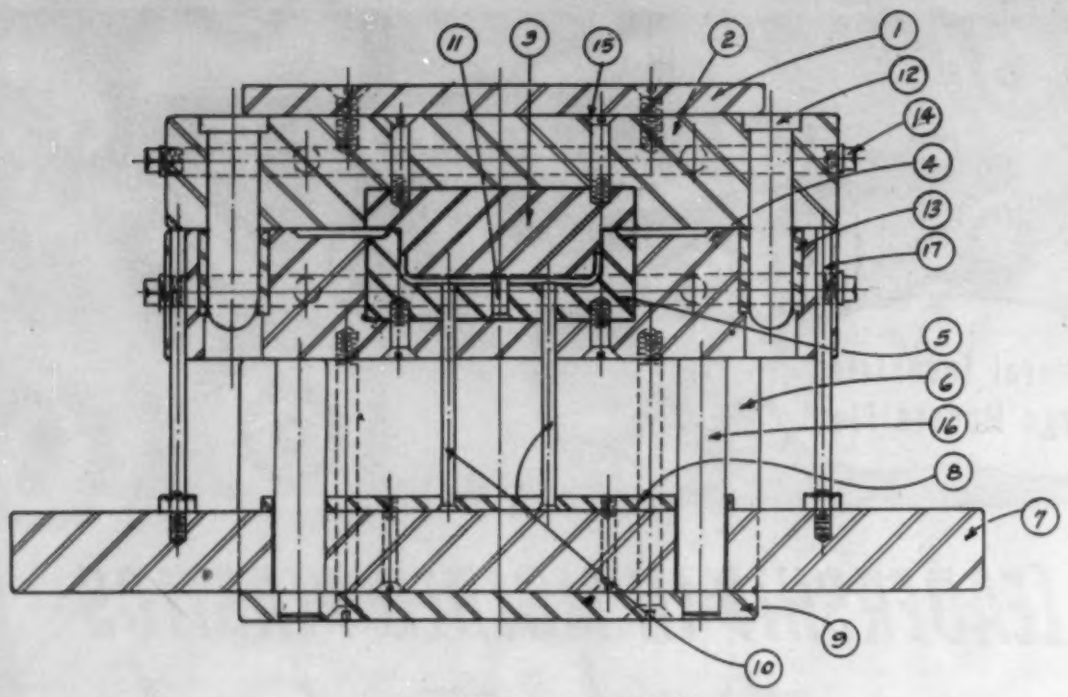


Fig. 4. Straight Plunger Mold

many; Where to channel the mold for heating; Number, size and location of knockout pins; Are the pins that mold the holes of correct diameter for the depth of hole to be molded; Are wedges required, and how shall they be located in the mold; Are pull pins required; Shall the mold be built in sections or in one piece; Where shall draft be allowed and how much; etc.

The designer should always keep in mind the ultimate cost of the tool but not at the expense of the part which is to be produced.

Number of cavities.—A difference of opinion prevails as to the correct number of cavities which may be put into a mold, as in Fig. 6, to give the maximum efficiency and the lowest cost of parts produced. In deciding on the number of cavities to be built into a mold the first information required is the number of molded parts required by the customer over a period of three months or longer, and what his daily or weekly requirements will be. If these requirements are very small, usually a single cavity mold will be large enough to take care of production. As the quantity to be ordered increases, it will be necessary to increase the number of cavities in the mold to the point where the individual molder feels he can realize the greatest output from his press equipment at the lowest cost. It is quite often necessary to limit the number of cavities in a mold due to the size of the part to be molded, or to the design of (*Please turn to page 217*)

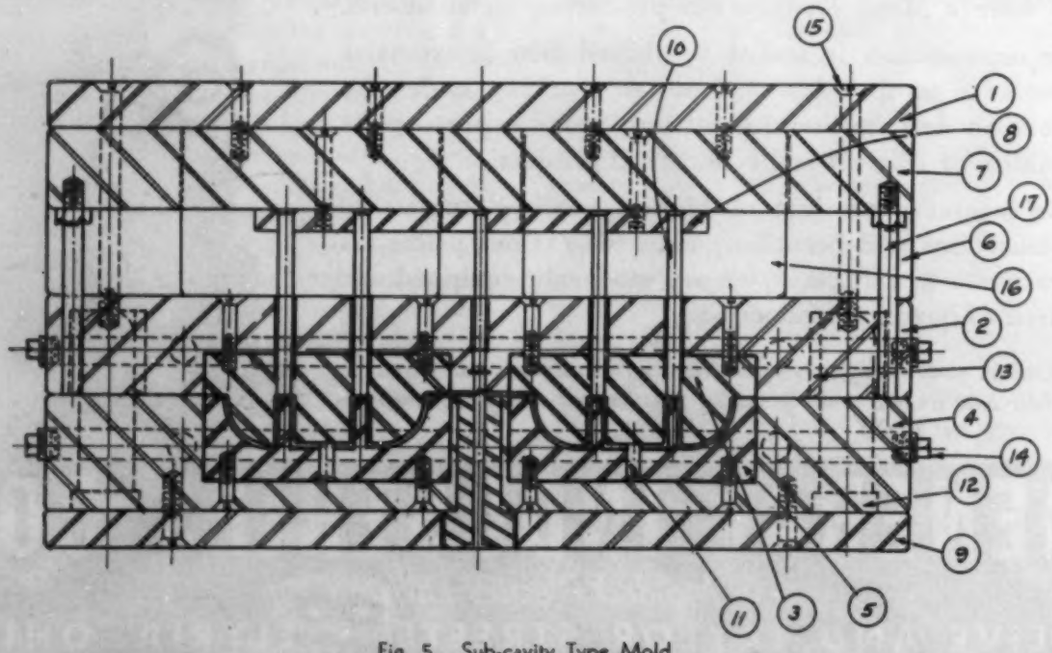
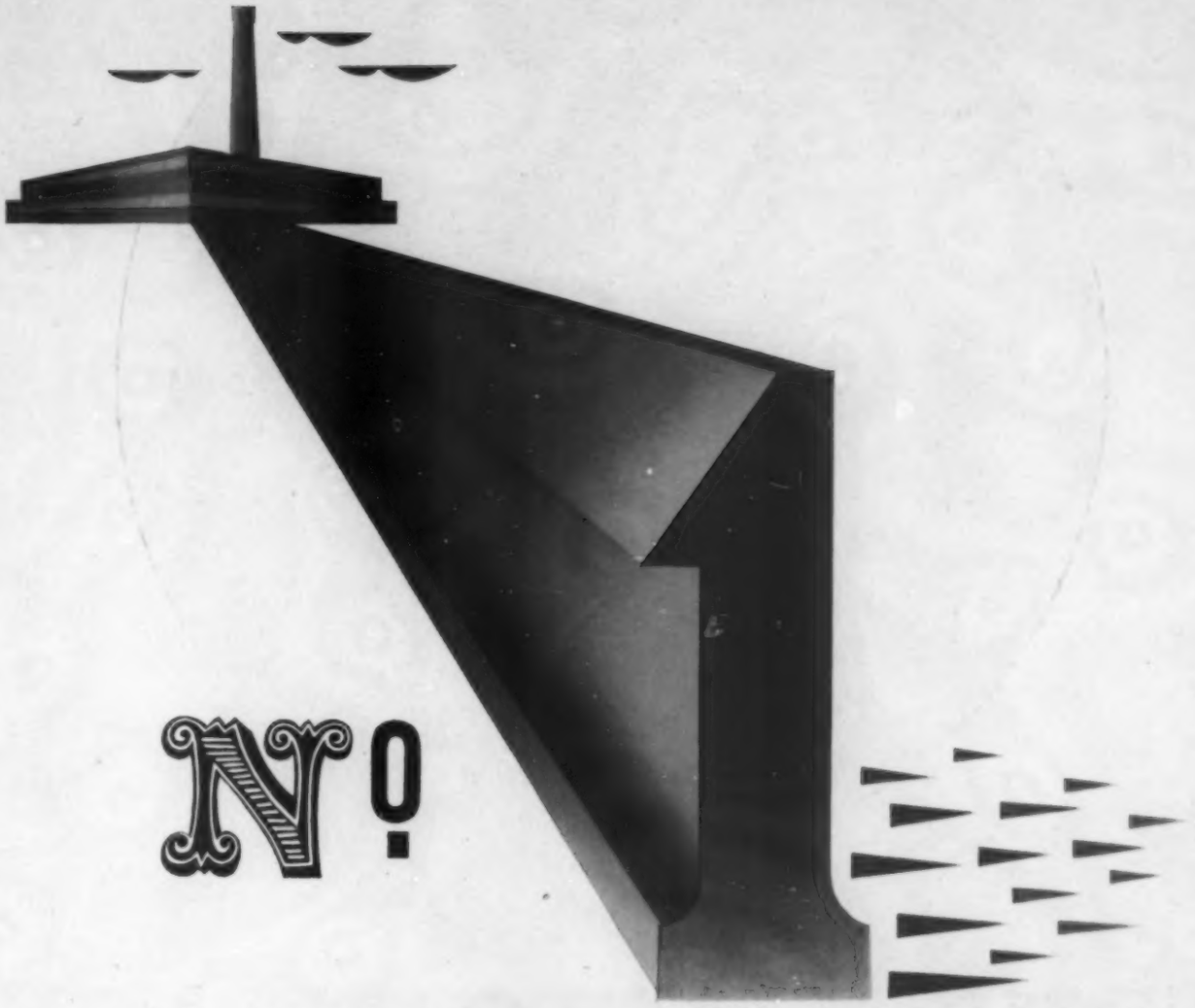


Fig. 5. Sub-cavity Type Mold



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TEXTOLITE
COMPRESSION MOLDED

NUMBER ONE PLASTICS AVENUE—where complete plastic facilities are at your service—is the home office of the Plastics Department of the General Electric Company. Hundreds of people, from all parts of the country, who visit it acclaim its complete modern equipment and experienced personnel. It is geared to provide the user of plastics with any phase of plastic molding and laminating he requires. Plastics in all of its many forms is becoming one of the most important materials in industry. On many of the products bought for the home, in radio, transportation, communication, aviation, lighting, • • •

RESEARCH AND DEVELOPMENT

TEXTOLITE

INJECTION MOLDED

building, and in many other branches of industry, plastics are used to make living simpler, more colorful, and more comfortable. For the industries that make all of these products possible, plastics help provide lower costs, simplified assembly, finer appearance, beautiful colors, permanent finish, more durable construction, and extra profits through more salable merchandise. That is why General Electric has provided NUMBER ONE PLASTICS AVENUE (as well as the other Plastics Department branches in Lynn, Mass., Meriden, Conn., and Fort Wayne, Ind.) with all of the advanced materials and machinery • • •

DESIGNING AND STYLING

TEXTOLITE

LIGHTING SPECIALTIES

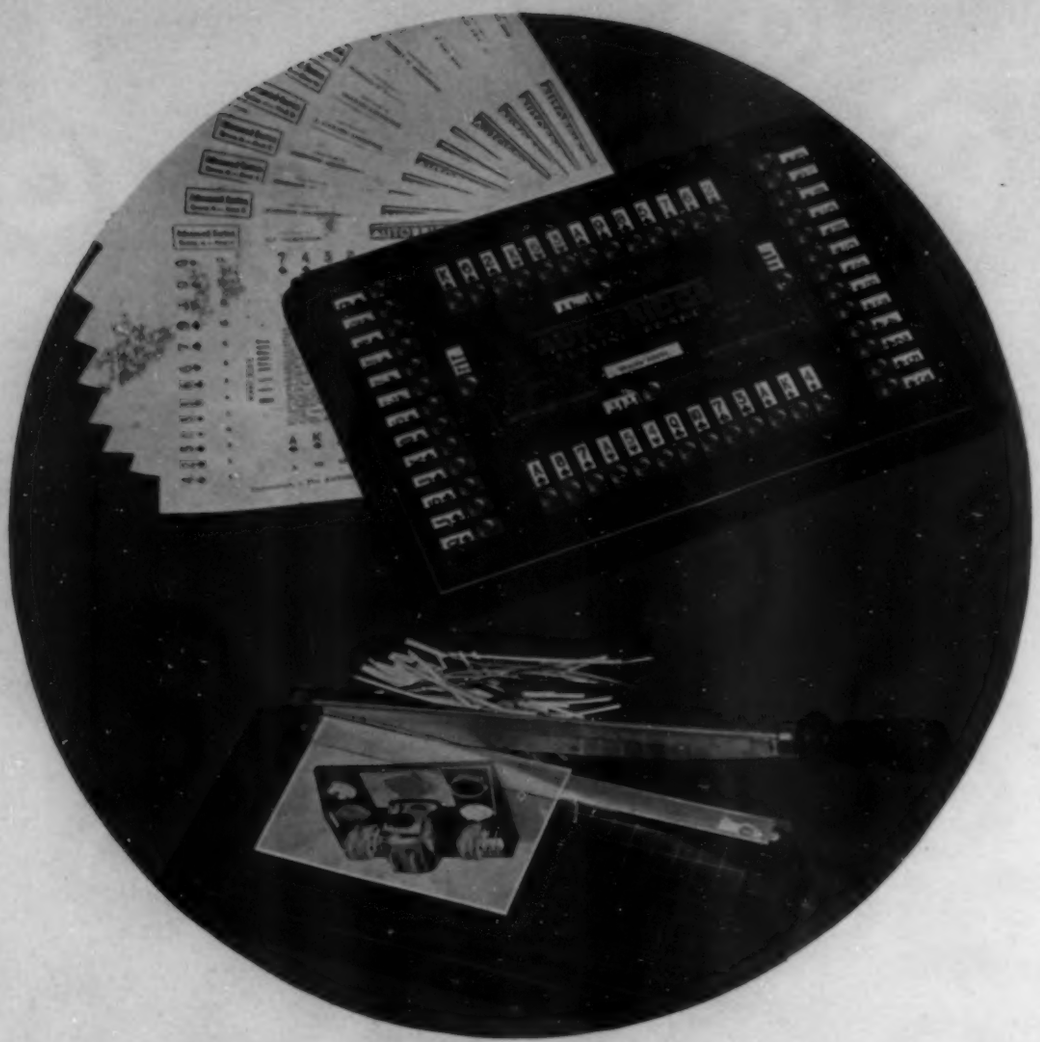
so that those who come to General Electric with their plastic problems can be sure that they are in reliable hands and that the ultimate results will be to their satisfaction. Research and development in the production of new Textolite molding compounds and varnishes, which are continually opening up new fields for plastics, are two of General Electric's contributions to the plastic industry and to the users of G-E Textolite, who eventually benefit from them. G-E designing and styling have become an indispensable service to many buyers of Textolite who desire good functional design combined with modern, . . .

APPLICATION ENGINEERING

TEXTOLITE
COLD-MOLDED

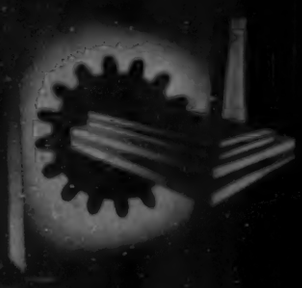
smart lines. Then, too, the customers know the advantage of having the molder do their styling; for with a complete knowledge of plastics and what can be done with them, extra economies usually result. Co-operating closely with the designing and styling department are G-E application engineers, who fully acquaint themselves with the function and mechanism of the customer's product. They are invaluable in guiding the stylist to practical designs. With the completion of the styling and engineering of the part, embodying smart design and practical moldability, it is the toolmaker's responsibility to design the correct . . .

MOLD MAKING

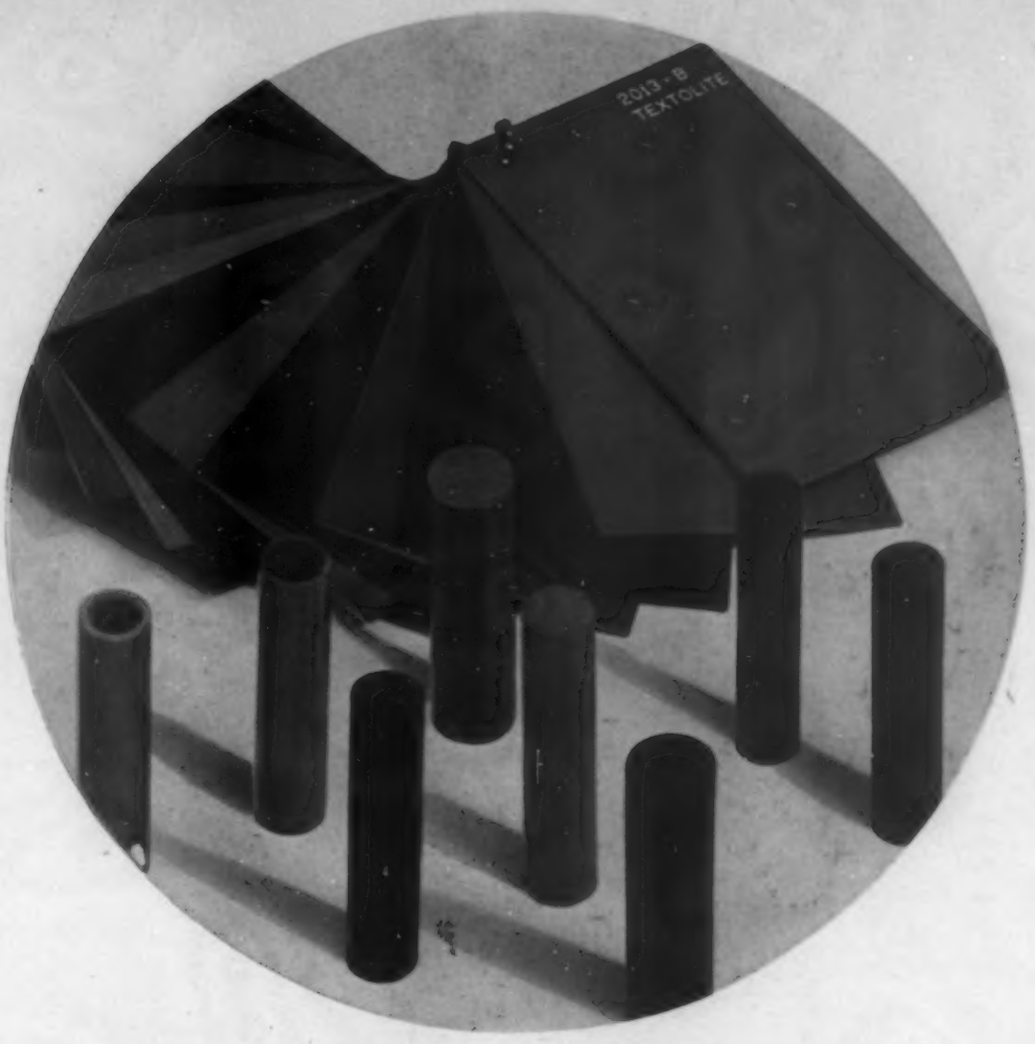


TEXTOLITE
MOLDED-LAMINATED

type of mold to assure easy and economical molding in the press room. At NUMBER ONE PLASTICS AVENUE, where General Electric supervises the careful making of all customer molds, craftsmen with an average of 18 years' experience in mold designing are busy profiling, drilling, hobbing, fitting and polishing the steel molds to precise finished dimensions. Because the plastic part is no better than its mold, G-E insists upon extra care and the use of only the most modern tool equipment. In the press rooms, row after row of presses (both of the compression and the injection types) ranging in size from 7 tons . . .



MANUFACTURING



TEXTOLITE
LAMINATED

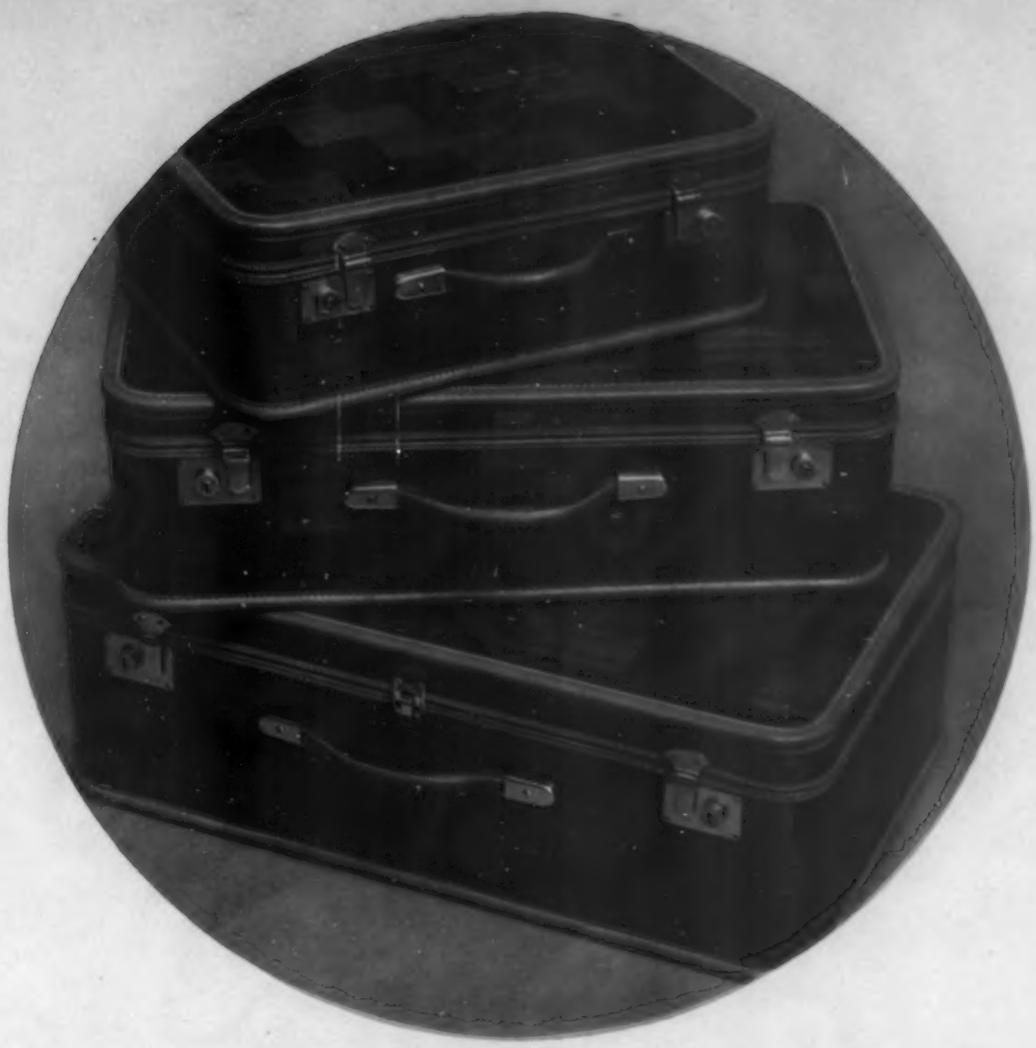
to 1500 tons, are operated by skilled operators—the backbone of the Plastics Department's manufacturing facilities. Such a wide range of press equipment makes possible fast and uninterrupted production, and close supervision by qualified men assures continuous high quality and uniformity. General Electric has added another service to its already extensive facilities by equipping a section of its Meriden, Conn., plant for the fabricating of Textolite laminated materials. Here, G-E will saw, strip, drill, thread, punch, slot, bevel, cut, and tap Textolite sheets, rods, and tubes to the exact requirements of its many . . .

FABRICATING

PARKWOOD TEXTOLITE

customers. Full supervision from the laboratory through treating, manufacturing, and fabricating results in greater product control, steadier production, and quicker, dependable service. From the press room, all Textolite plastic parts flow into the finishing room. There the parts are drilled, tapped, filed, sandpapered or buffed, in accordance with the customer's specifications and requirements. This final operation completes the manufacture of the Textolite parts you buy, and the careful inspection that follows, plus the use of modern shipping facilities, completes the many phases of the plastics service that • • •

FINISHING AND INSPECTION



PARKWOOD TEXTOLITE

NUMBER ONE PLASTICS AVENUE provides. Close commercial contact with a plastic specialist within easy reach of your phone will speed your requirements to the home office for quotation, styling, and recommendations. That General Electric can meet every plastic demand and can help you realize worth-while economies is indicated by the following six plastic problems that have been solved THE G-E WAY. Read them carefully. Perhaps you have similar problems? In any event, you will find NUMBER ONE PLASTICS AVENUE a logical and dependable source for molded, laminated, and cold-molded plastics.

COMMERCIAL CONTACTS

PLASTIC PROBLEM NO. 1

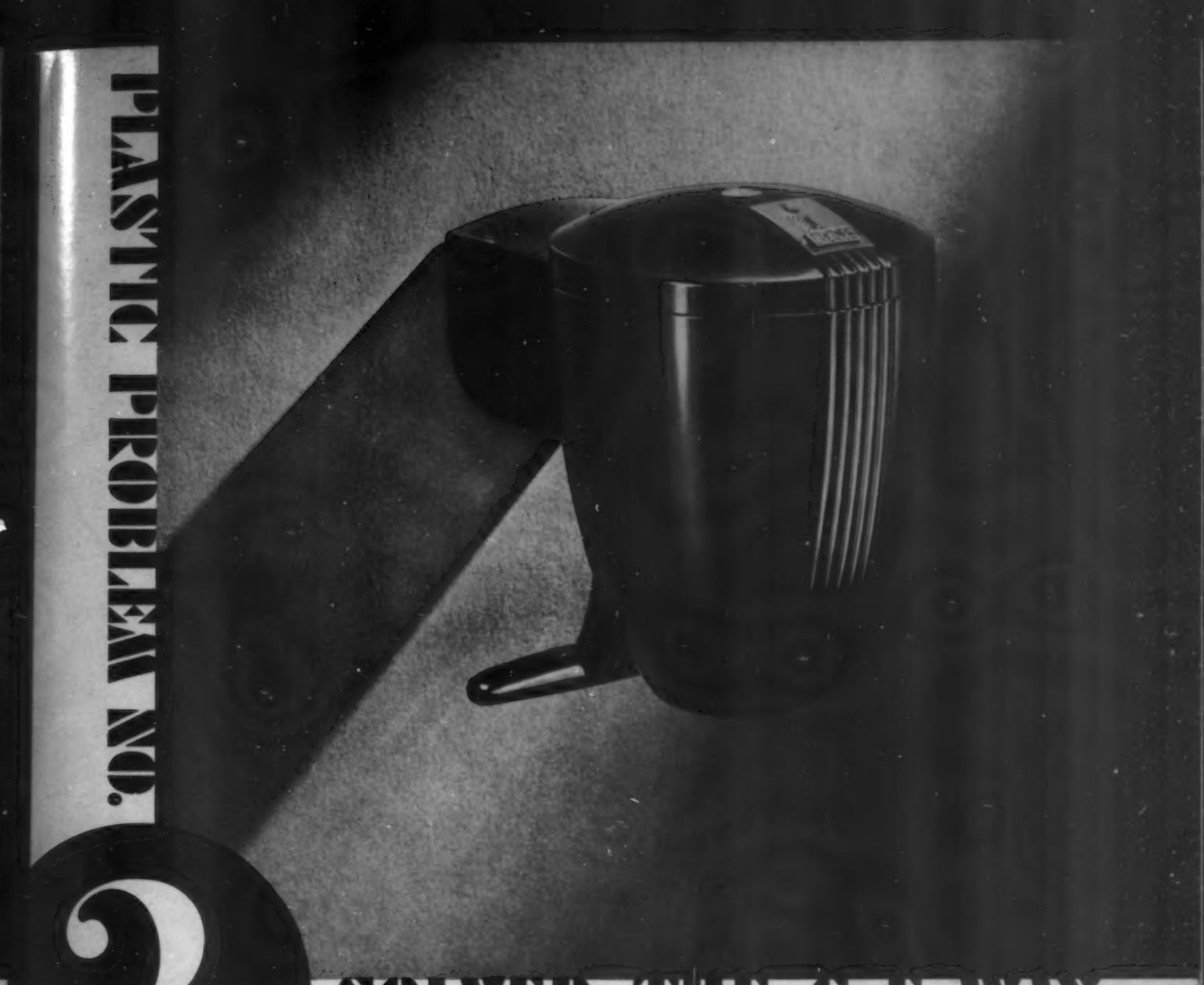
SOLVED THE G-E WAY

PARTS: Textolite molded housing and cover. **USE OF PARTS:** Used as the complete housing for the new Gillette Dry Shaver, manufactured by the Gillette Safety Razor Co., Boston, Mass. **CUSTOMER'S PROBLEM:** The Gillette Dry Shaver provided two molding problems, involving undercuts and metal inserts molded-in at an angle. The off-set head was necessary to secure a natural shaving angle, and streamlining the connector plug so that it would become a part of the razor design required a through slot, open to the sides, in the molded housing. **SOLVED THE G-E WAY:** First, G-E design engineers suggested slight changes in the location of the parting line of the housing and cover to provide a better fit, improve the appearance, and assure greater molding economy. This change in design placed both of the major problems in one part, the housing. Overcoming these problems was a matter of sound engineering in the designing and building of molds, and the use of modern machine tools. G-E mold designers constructed the molds so that the parts could be molded in regular, fast production with maximum ease, quality, and economy. ● Mold design is one of the important phases of superior molding. On it depends the successful molding of difficult jobs, like the Gillette housing. General Electric offers you the same engineering, designing, and manufacturing facilities. There is no better way for simplicity, reliability, and economy than THE G-E WAY. For information, write Section R-19, Plastics Dept., General Electric Co., One Plastics Ave., Pittsfield, Mass.

GENERAL ELECTRIC

PLASTIC PROBLEM NO.

2



SOLVED THE G-E WAY

PARTS: Textolite Soap Dispenser Assembly. **USE OF PARTS:** This Textolite soap dispenser assembly consisting of five parts—main body, dispensing lever, cover, nameplate, and mounting bracket—is for the Pax Soap Dispenser manufactured by the G.H. Packwood Manufacturing Co., St. Louis, Mo. **CUSTOMER'S PROBLEM:** A complete mechanical redesign of this product to provide minimum molding costs consistent with good functional design. **SOLVED THE G-E WAY:** With the co-operation and help of Mr. G. H. Packwood, Jr., G-E engineers transformed the original dispenser design into a sturdier, more attractive product, mechanically sound and economical to mold. For instance, General Electric suggested a change in the mounting bracket from a round contour to its final shape to assure better moldability; while a change in the lever mechanism reduced mold costs and improved operation. Other small but important improvements, such as the captive cover that cannot be dropped and the method of affixing the nameplate, also contributed to minimum molding costs consistent with good functional design for the Packwood Company. Such engineering and designing co-operation, combined with General Electric ability and molding facilities, make THE G-E WAY your most dependable source of supply for plastics in molded, laminated, or cold-molded forms. Let us help you too. For complete information and recommendations, write Section R-29, Plastics Department, General Electric Company, One Plastics Avenue, Pittsfield, Mass.

GENERAL ELECTRIC

PLASTICS PROBLEM NO.

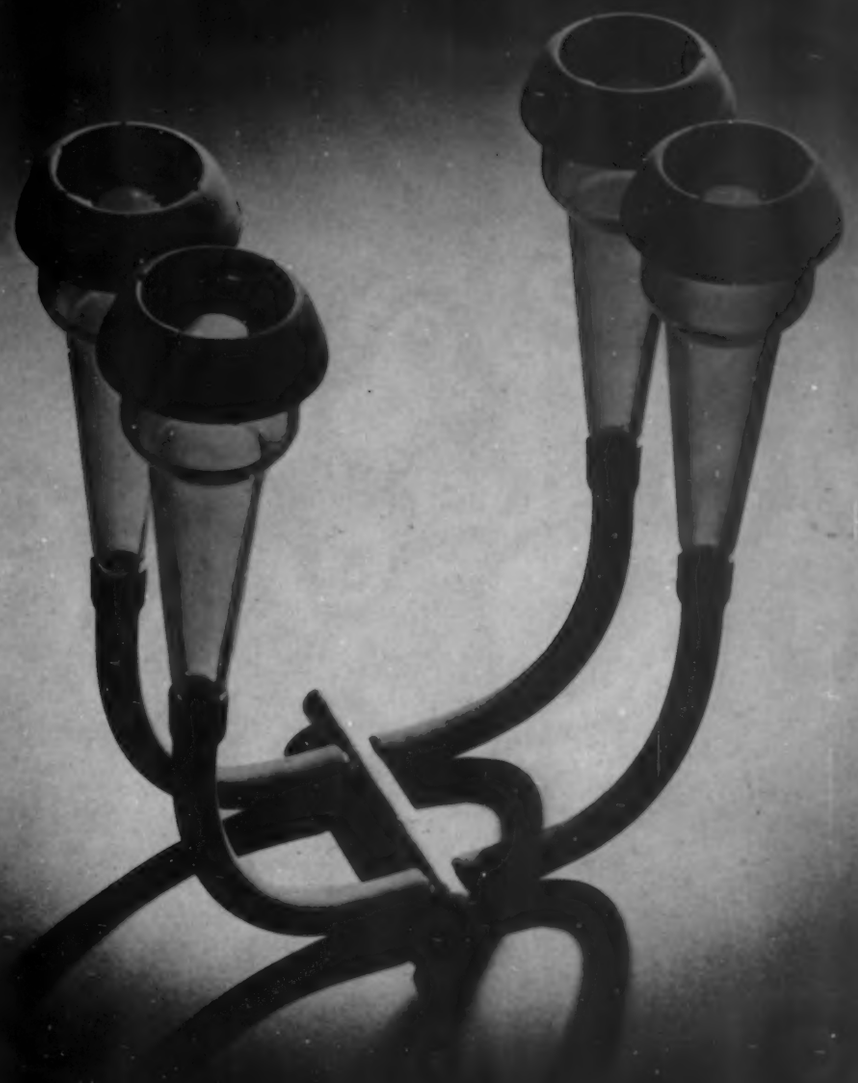
3

SOLVED THE G-E WAY

PART: Textolite molded-laminated base. **USE OF PART:** Used as the base for the new trimming board made by the Besbee Products Corporation, Trenton, N. J. **CUSTOMER'S PROBLEM:** To produce an improved photographic-paper cutter, light in weight, modern in design, attractive, and durable. **SOLVED THE G-E WAY:** First, a careful study of the application by G-E engineers and the choosing of the type of Textolite material that would provide maximum strength at lowest cost. The logical selection was Textolite molded-laminated, a technique recently developed by General Electric. Molded-laminated would give this base the highly lustrous finish of molded plastics and the tough, strong structure of laminated plastics. Next, General Electric recommended its hot roll leaf facilities for the white lines and figures, which reduced the cost of this operation nearly 1500 per cent from that of the ordinary rub-in method. A decision on the type of mold to be used to assure economy and adequate production completed THE G-E WAY of giving Besbee Products the largest possible return on its investment. No matter what the application may be, you will find a Textolite material, special molding facilities, and a competent staff of G-E engineers ready to help solve your molding problem. The advantage of doing business with a dependable molder who can offer you a complete plastics service saves you money in the long run. For complete information and recommendations write Section R-39, Plastics Department, General Electric, One Plastics Avenue, Pittsfield, Mass.

GENERAL ELECTRIC

PLASTICS PROBLEM NO. 4



SOLVED THE G-E WAY

PARTS: Textolite transparent teat cups. **USE OF PARTS:** Used on the Clean-Easy Portable Milker, made by the Ben H. Anderson Mfg. Co., Madison, Wisc. **CUSTOMER'S PROBLEM:** A material replacing metal was necessary to resist corrosion caused by the lactic acid in milk, and to withstand a daily washing with a lye disinfectant. The difficult shape offered an unusual molding problem. **SOLVED THE G-E WAY:** Various grades of Textolite were tested by the customer to determine which grade provided the required characteristics. It was found that a pure resin plastics was most suitable and being transparent it also gave the Anderson Co. one of its most important sales points—that is, the dairymen can watch the milking operation and see that the teat is milking properly. Another requirement was smoothness for easy cleaning. As General Electric supervises the making of all customer molds it was a simple matter to give the customer parts with extra-smooth surfaces. Finishing, after molding, required special facilities and a method of cleaning unlike the standard procedure. A wide range of plastic materials offering various combinations of properties; self-contained modern tool rooms with close supervision of customers' molds; and complete facilities that easily permit out-of-the-ordinary methods to give the customer what he wants, are only three of the many phases of General Electric's custom molding facilities. Combined they comprise THE G-E WAY—your way to better service and quality in plastics. For complete information, write Section R-49, General Electric Company, Plastics Department, One Plastics Avenue, Pittsfield, Massachusetts.

GENERAL ELECTRIC

PLASTIC PROBLEM NO.

5

SOLVED THE G-E WAY

PARTS: Textolite molded trophy bases. **USE OF PARTS:** Used as the pedestals for trophies manufactured by the International Silver Co., Meriden, Conn. **CUSTOMER'S PROBLEM:** The customer wanted molded bases for beauty, fine finish, colors, and lighter weight, but the limited quantities of each size trophy base produced prohibited the investment in molds for all sizes. **SOLVED THE G-E WAY:** To solve the customer's problem, General Electric called on its plastics styling and designing department. The solution was an ingenious design of three carefully styled parts. By means of interchanging and pyramiding, these three parts provided the customer with nine different and attractive trophy bases. The investment in only three molds, instead of nine, made this Textolite application practical and economical for the International Silver Company—another outstanding example of THE G-E WAY in plastics. This design feature also makes possible beautiful color combinations, and the parts are so made as to allow the use of metal trim with startling contrasting effects. Will design and styling be the answer to *your* plastic problem, too, or will some other G-E facility, such as research, development, engineering, or manufacturing help in fulfilling your plastic requirements? General Electric offers you its complete molding service. Make use of any one or all of its branches and make sure of high quality and sound functional design. For complete information, write Section R-59, Plastics Dept., General Electric Co., One Plastics Ave., Pittsfield, Mass.

GENERAL ELECTRIC

PLASTICS PROBLEM NO. 6 SOLVED THE G-E WAY

PART: Textolite molded rack. **USE OF PART:** Used as a holder for Victor and Bluebird records manufactured by the RCA Mfg. Co., Inc., Camden, N. J. **CUSTOMER'S PROBLEM:** The selection of a material that would permit construction of this design and provide smooth, nonscratching surfaces with good appearance. **SOLVED THE G-E WAY:** Plastics was the most practical and economical material to use. It became a matter of applying General Electric's years of molding experience and putting into use its many facilities to make the holder acceptable. General Electric's contribution was fivefold. First, the mold construction was difficult because of its size and the intricacy of the thirty-nine curved record spacers placed every 5/16 of an inch apart. The spacer grooves had to be machined out of solid steel blocks to eliminate parting lines and thus assure smooth surfaces in the finished part. Second, by suggesting a change in design, the weight was reduced with no sacrifice of strength and an appreciable saving of compound was effected. Third, a method of controlling warpage due to the narrow curved spacers was devised and successfully put into effect. Fourth, a new and inexpensive way of printing was developed for the numbers and trademark. Fifth, General Electric suggested means of affixing the bumper plates to the holder, thus helping to reduce the customer's assembly cost. What can THE G-E WAY contribute toward the successful and economical molding of your plastic requirements? Write Section R-69, Plastics Department, General Electric Company, One Plastics Avenue, Pittsfield, Massachusetts.

GENERAL ELECTRIC

OFFICES

920 Western Ave., West Lynn, Massachusetts
34 Cambridge Street, Meriden, Connecticut
1405 Locust Street, Philadelphia, Pennsylvania
570 Lexington Avenue, New York, New York
700 Antoinette Street, Detroit, Michigan
230 South Clark Street, Chicago, Illinois
4966 Woodland Avenue, Cleveland, Ohio

PLANTS

Pittsfield, Massachusetts
West Lynn, Massachusetts
Meriden, Connecticut
Fort Wayne, Indiana

GENERAL ELECTRIC

(*Continued from page 200*) part to be molded. In such cases if the number of cavities required is more than can be put into one mold, additional molds will have to be built. Another limiting feature in deciding on the number of cavities to be made is the platen area of the available press equipment, and the tonnage delivered to the platen by hydraulic pressure or other means with which the individual molder's plant is equipped.

Size of Press Required.—Press size as discussed here is the amount of tons per square inch which can be produced by a ram actuated by hydraulic pressure or other means. Considerable care must be taken in designing a mold to see that the mold will fit into a press with adequate pressure. If too low a pressure is used, the molded parts will be inferior in quality and extra time will have to be spent on finishing operations. On the other hand, too much pressure may readily result in damage to the mold, which means high mold maintenance and loss of production. Different types of molding materials may require different pressures to mold satisfactorily, so the designer must thoroughly check the material to be used.

Type of Material.—There are a great many different types of materials used in molding, and some of them require more filler or loading space designed into the mold than others. If preforms are to be used, less loading space is required, also, than if the material is loaded in bulk. It is well to keep the loading space of a mold to minimum requirements in order to make the mold less costly. If mold pins are required to enter the plunger, it is an advantage to keep the loading space down, as damage to the pins is less likely to occur, due to their shorter length, and consequently, greater strength.

Shrinkage Allowance.—Manufacturers of molding materials have, and are continually making tests to determine the shrinkage allowances that are to be used for the various types of materials which they produce. These shrinkage allowances must necessarily be an average of several tests as different batches of material may show different shrinkages, and a figure must be arrived at which will show the least variation after the material is molded. The designer adds the correct amount of shrinkage per inch to the dimensions which he puts on the drawing or sketch from which the tool is to be made, and if the tool is made to these dimensions it may be expected to produce a molded part within the tolerances provided on the part drawing, if the tolerances on the part drawing have been added by a draftsman familiar with molding practice.

Tapers.—An extremely important factor which is oftentimes overlooked is the placing of taper, or draft, on all parts wherever possible. If a molded part requires straight sides, it can be done, but with much more difficulty than if taper could have been allowed. This subject of taper should be thoroughly discussed with the customer so that an understanding can be arrived at before the mold is designed and built.

In summing up the subject of design of molds it can readily be understood that designers of actual mold making experience, molding experience, and other functions of a molding plant, are necessary in order that the individual molder can satisfy his customers with a quality product at a satisfactory price.

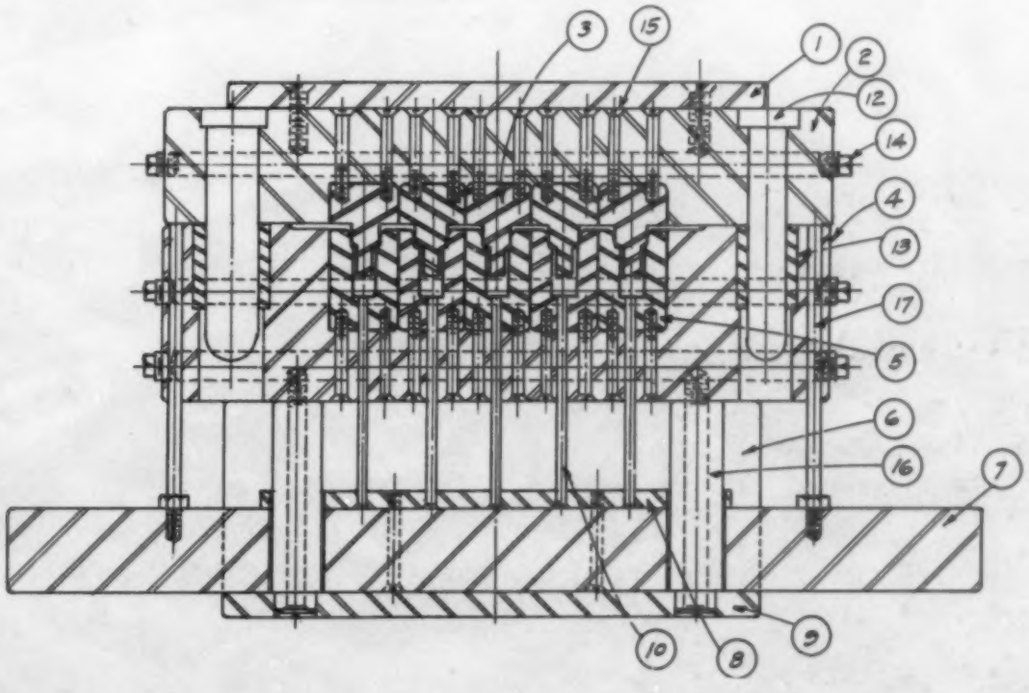


Fig. 6. Number of Cavities

PREFORMING

by KENNETH IREY*

PREFORMING FOR THE PLASTICS INDUSTRY consists of compressing the various types of molding powders into "pills" or tablets. This is accomplished with special machines constructed for this purpose. These machines are of two general types, namely, the single stroke machine and the rotary. Essentially both of these types of machines work on the same principle in that the molding powder is placed in a hopper and a predetermined quantity or weight is automatically fed to the die or dies and sufficient pressure is applied to the charge of molding powder in the die to compress these many granular particles into a tablet. The rotary machine is more generally used for the more simple type preforms having a capacity of 250 to 400 pieces per minute. The single stroke machine is more generally used for large or more intricate types of preforms and it has a capacity of 50 to 150 per minute. These machines are adjustable so that various weight preforms of the same general shape can be made on the same dies; they are also adjustable for hardness of preform.

The older method of handling was to weigh charges of molding powder for each cavity in small cups and charge each cavity by hand. The inefficiency of this method and inability to turn out the many millions of pieces molded today is self evident. From this stage the industry advanced to using loading boards which are still used in some shops. These consist of boards with holes for each mold cavity of a definite size and shape. There is a shuttle fastened to the bottom which is closed when the board is being loaded and tripped to drop the molding powder in the cavities when the board is placed over the mold. For loading, the molding powder is poured on the board and the excess scraped off. Most loading boards of this type are not adjustable to compensate for the variation in the apparent density of various molding powders which results in considerable waste due to short-weight pieces or excessive flash. Even though the board is made to contain the correct charge for one particular powder it is often over-charged due to the bench or board being jarred which results in settling an excess of powder in the loading cavities.

(Please turn to next page)

* Resinox Corp., Subsidiary of Monsanto Chemical Co.

Typical preforms of a wide variety are pictured below. Their shape frequently indicates their eventual use but the majority of preforms are in the shape of tablets, rings and balls. Those shown were preformed on Stokes tablet compressing machines

ADD STRIKING BEAUTY

And Greater Sales Appeal

AT LITTLE COST

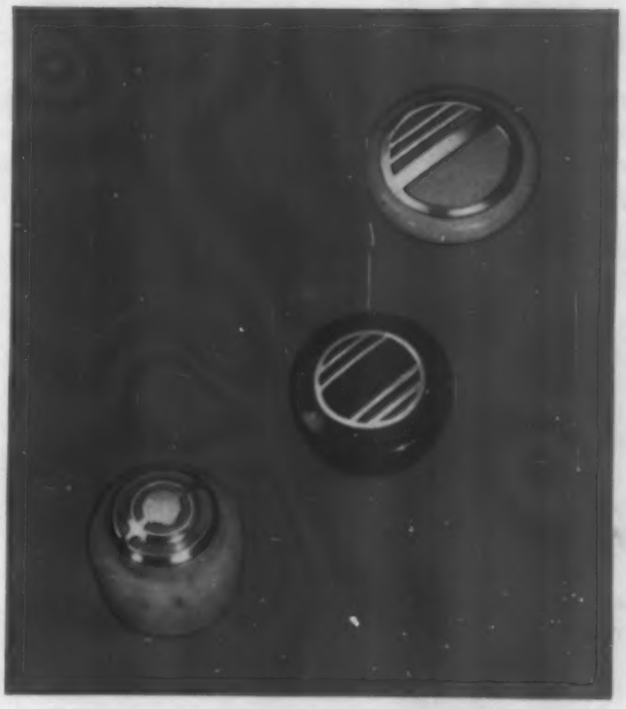
With the CHILTON *Inlaying Process*

Stainless steel, chrome brass, or any other workable metal—permanently inlaid by the exclusive CHILTON Inlaying Process—will bring immeasurable beauty, display value and dramatic sales appeal to your product.

Distinctive decorations and attractive trademarks, names, and numerals may be readily and permanently embedded in any shape or contour of plastic articles—and in any type of plastic, whether it be ureas, phenolics, cast resins or acetates.

By the patented CHILTON Inlaying Process, these metal inlays may be inlaid in your product so that they are proof against time and hard usage.

Costs are surprisingly low. Send us a sample of your product. We will gladly advise you on how you can take full sales advantage of the new CHILTON Inlaying Process.

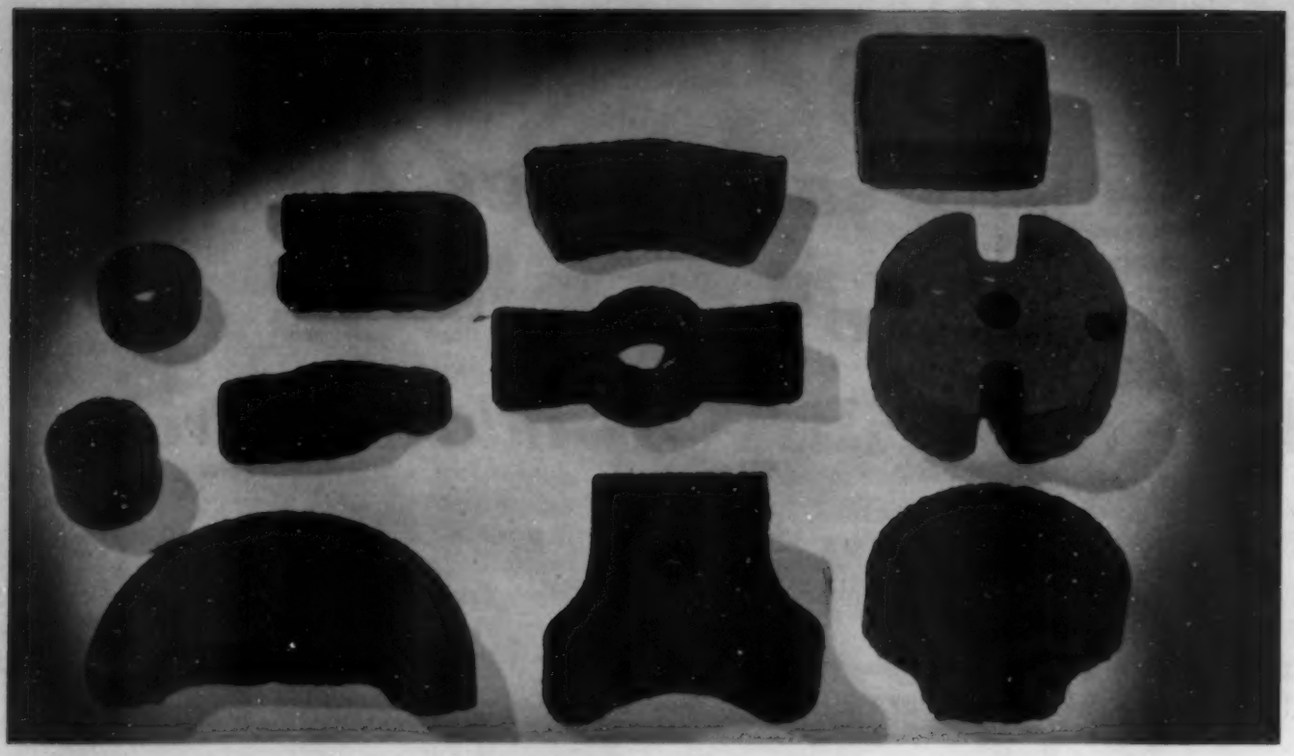


The Automotive Industry now uses Chilton Inlaying Process to dress up plastic parts. Above are typical 1940 model applications.

PLASTIC INLAYS INC

The CHILTON PROCESS
INSURES DURABILITY

MAIN OFFICE: SUMMIT, N. J.
Detroit, Mich., Stevenson Building
Chicago, Ill., Wrigley Building



Preforming condenses the molding compound so that molds are more quickly and easily filled, insures an accurate charge to each cavity, and prevents waste of compound. Difficult shapes are sometimes molded easily by providing each cavity with a preform of almost the identical shape of the molded part. Those shown came from Northern Industrial Chemical Company

Preforms are also usually handled with a similar type loading board. The preforms are poured on the loading board and then it is shaken in order to have the preforms settle in the cavities on the board. In order to avoid spillage it is advisable to have a raised rim on the front and sides of such loading boards.

The preforming of molding powder is essential to the efficient operation of molding plants for the following reasons:

1. *Accuracy of weight.* To keep waste at a minimum it is essential to have a definite quantity of molding powder for each molded piece and preforming is the only satisfactory method of obtaining this uniform weight. This weight is usually 10 percent over the actual weight of the finished molded piece. The extra weight is to insure that all pieces are completely filled because short pieces are rejected, which means a loss of the powder and labor involved. Theoretically it should be possible to operate with no flash but in practice it is found that the material may start flashing on one side of a piece before the other side is filled which results in a short piece. Some shops run with as low as 5 percent flash which is generally due to the cavities in the molds being more uniform in size than they are in the average shop. On the other hand, excessive over-weight results in a large unnecessary flash loss and it may even result in heavy fins or the flash sticking to the land of the mold. This flash can be removed but it costs money.

2. *Space saving.* Many flash molds today are so shallow they will not hold the necessary volume of loose powder which has a bulk $2\frac{1}{2}$ times that of the final molded piece, while preforms are roughly only $1\frac{1}{8}$ times the bulk of the finished piece. Preforms also aid in getting a concentration of material in one portion of the mold which at times is especially desirable when molding with long inserts as an excessive flow of powder tends to bend or dislodge them. In other cases it may be difficult to fill a certain section of a molded piece and often a concentration of material at this point is an aid in getting completely filled pieces.

3. *Aid in preventing precure.* When charging loose powder into a mold cavity some of the fine powder adheres to the mold surface and often before pressure is applied some of these little particles have been heated sufficiently to precure which results in a poor finish on the final molded piece. This is less likely to occur when preforms are used since all the cavities of the mold can be loaded faster and the mold closed sooner, and there are no small particles to adhere to the surface of the mold.

4. *Aid in distribution of mottles.* When mottles are used for making molded specimens usually a more uniform distribution of the components is obtained when

Bombyx mori
a la plastics
FOR countless years Bombyx mori has labored in seclusion, unheralded, to create the dainty filaments from which silk is spun. Production was slow, limited, lacking in uniformity, and Bombyx mori's interest ceased with the filament—the remainder of the job was passed on to others.
The Industrial Rayon Corporation, utilizing the aid of plastics, set about to create a synthetic Bombyx mori. The result, after years of painstaking research and experiment, is continuous production that begins with liquid rayon and ends with completely finished yarn of unvarying uniformity.
From the spin tanks in which the liquid rayon is extruded, the filaments are carried over a series of ingenious, acid-resisting, non-hygroscopic, thread-advancing plastic reels, precision molded by Richardson, through all stages in processing, cleansing, drying and twisting operations to INSUROK plastic bobbins on which the yarn is first wound up. Except during drying and twisting, the filament comes in contact only with plastics until the rayon yarn is delivered to the coning room.
Today ninety-six units, each equipped with 900 plastic reels, annually produce 12,000,000 pounds of finished rayon of an excellence of quality and accuracy of denier not possible under old methods. Thus plastics continue to play their increasingly important part in the commercial and industrial development of the nation.
INSUROK
Of known physical, chemical and dielectric qualities, INSUROK, the precision plastic, is available in forms and grades to meet every requirement. Consult Richardson technicians, without obligation, on any problem involving the use of plastics. Get in touch with the office located nearest you.
The RICHARDSON COMPANY
RICHARDSON PRECISION PLASTICS

Appearing in
FORTUNE
in October, 1939

THE significance of the Industrial Rayon Corporation installation of almost 90,000 plastic thread-advancing reels, and numerous other Richardson precision molded parts, is two-fold. 1) Man-power and machinery geared up to the volume production of intricately molded parts and finished products to exact tolerances. 2) A staff of plastics technicians in design, research and engineering laboratories whose specialized abilities have proved invaluable in solving difficult plastics problems. Small wonder, then, that plastics users instinctively turn to Richardson for their requirements.

★ Richardson is also equipped for volume production of injection-molded thermoplastics.

The RICHARDSON COMPANY

Melrose Park, (Chicago) Ill. *Founded 1858* Lockland, (Cincinnati) Ohio
New Brunswick, N. J. Indianapolis, Ind.

Detroit: 4-252 G. M. Building. Phone, Madison 9386 New York: 75 West Street. Phone, Whitehall 4-4487

preforms are used. This results usually in a better-looking molded piece with more uniform mottling.

5. Convenient handling for preheating. Although not all molders practice preheating, those who do, find it simplified when preforms are used as the preforms are conveniently transferred to and from ovens or steam platens used for the preheating operation. I might add that preheating enables molders to obtain a faster cycle in the mold and usually results in better finish and less warpage trouble—this is particularly true of colored molding powders.

6. Aid in reducing contamination. It quite often happens that black material may be running on both sides of a press where a white is being molded. If loose powder is used the drift of the black powder necessarily contaminates the lighter color and it often results in excessive rejects. The use of preforms materially reduces the floating dust in a shop, making it possible to mold white and black in adjoining presses.

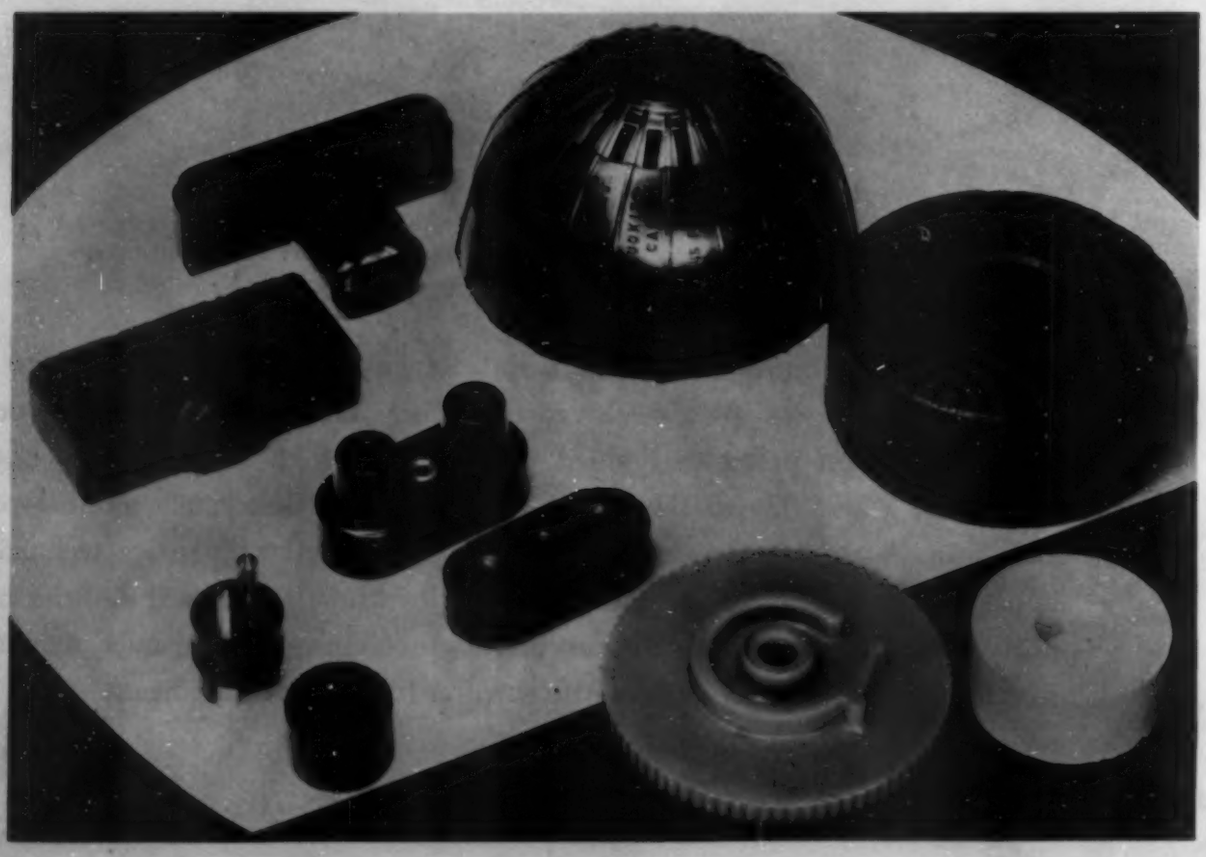
7. Cleanliness and housekeeping. The use of preforms is a material aid in keeping a shop in an orderly and presentable appearance. Molding powder is necessarily dusty and dirty if it is not kept confined and there is no way to confine it. When preforming equipment is used it is practicable to install dust-collecting apparatus in the preform room thus minimizing the dust factor and keeping it away from the presses and operators.

Types of preforms vary over a wide range, chiefly depending upon the type of mold and the type of piece being molded. In general it is desirable to approximate the shape of the piece being molded since this aids in proper distribution of the molding powder in the mold cavity. The varied shapes it is possible to make, at times, turn a particularly troublesome molding job into one that is simple and profitable.

Fibrous materials are often troublesome in preforming, the trouble usually being in obtaining uniform weights. This is largely due to the poor pourability of the material. An aid in overcoming this would be to suspend a rod from the top of the hopper to the toe of the shoe on a single stroke machine. The rod must necessarily be bent in order to pass it through the neck of the hopper and to the toe of the shoe. The shuttling of the shoe moves the rod which tends to keep the material feeding uniformly. Running the machine at a slow rate is also an aid in obtaining uniform weights.

The modern trend in the industry is to preform and mold in a continuous automatic cycle. This is beneficial for the industry since it means lower costs and will tend to enlarge the market for molded plastics. However, where such equipment is not yet available preforming is the most practical method of handling molding powder since it pays dividends in reduced waste and higher quality of molded pieces.

Chicago Molded Products Corp. uses accurately shaped preforms for molding intricate parts as indicated below in the Mixmaster Selector knob, American Stove Co. handle, Chicago Electric Co. connector assembly, Twin Jack body switch plug, and the Zenith radio tuning knob at the lower right



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Now Carterite makes possible contoured moldings in sizes limited only by the size of your presses. It makes moldings stronger than you dared believe were possible. And it makes them light in weight, beautiful in finish and permanent in characteristics. Carterite greatly widens the useful field of molded plastics.

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Carterite is a combination of fibres and plastic. The fibres are not broken down, but are practically in their original form, and these long, tough, interlaced, natural fibres are completely bound together by the plastic. Carterite is *not* a lamination. Carterite is a complete mixture, a solid, homogeneous material—beautiful, impervious, tough, and hard clear through.

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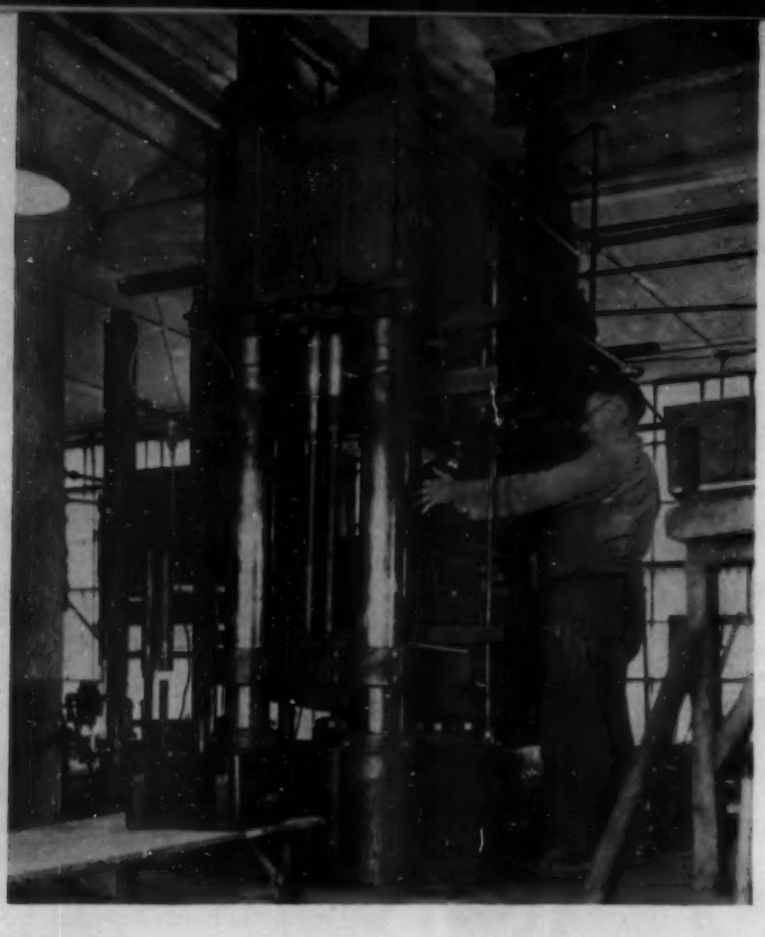

All compression molding presses are not this size but we choose this as our first illustration to indicate that big plastic parts such as radio cabinets, machine housings, etc., require sizable equipment to produce. This press is rated at one million tons pressure. (All photographs illustrating this story are by courtesy of Northern Industrial Chemical Co.)

COMPRESSION MOLDING

by J. C. FULLER*

COMPRESSION MOLDING IS THE TERM USUALLY applied to open mold construction—where the compressing plunger forms one of the finished surfaces of the molded piece. It is largely used for thermosetting compounds, but is sometimes used for thermoplastic materials. Methods other than compression include extrusion or transfer molding,[1] injection molding,[2] and continuous strip molding.

There is a special form of compression molding which deserves brief mention. It is known as *double molding*. In this process a preliminary top plunger is used to partially form the molded piece with suitable recesses to receive inserts or core pins. As soon as this plunger is pressed to its final position it is immediately withdrawn before the molding material is cured—the inserts or core pins are then placed in position—additional molding material is added—and then a second or final mold plunger presses the whole mass together until full cure is effected. This second plunger is of different shape than the preliminary plunger, and forms the final shape of the top of the molded piece. This process is not recommended unless the designer of the piece to be molded has a working knowledge of the various special problems and difficulties incident to successful accomplishment.

Before deciding which of the above mentioned methods of molding should be employed to form a piece, consideration should be given to the following points:

1. Ejection of piece from the mold.
2. Shape and position of inserts.
3. Size and position of small bore holes.
4. Consideration for the life of, and the upkeep expense on tools.
5. Loading of mold.
6. Proper heating of all parts of mold.
7. Pressure required to completely fill cavity.
8. Elimination of gases if urea compounds are the materials being molded.
9. Upward force of molding material flowing under high pressure.
10. Wedging action of long tapered plungers.

Following are a few comments on the above points, but no attempt will be made to discuss them in detail as would be required if this were to be a text-book on the subject in hand.

1. Ejection. It may strike the layman as being almost axiomatic that a mold would be designed so the piece could be ejected. He might also assume that it was an attempt to be humorous that such an obvious requirement of a molding method or mold should be given prime consideration. (*Please turn to next page*)

* Northern Industrial Chemical Co.
[1] See page 240.
[2] See page 232.

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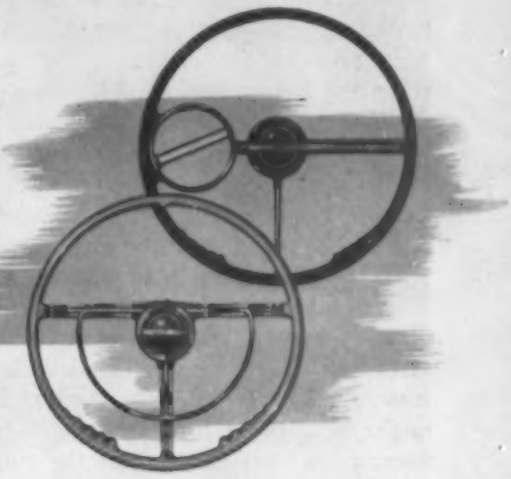

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May we count decimals and decibels to help produce for you a product which is stylish, quiet, shock-insulated and salable?

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Let me say that it does not by any means follow that a mold which will form an intricate piece will also eject the piece without distortion, even assuming it will eject at all. This question of ejection is one of prime importance, and although it determines mold design, it should—and frequently does—determine what method of molding will be adopted to produce pieces to the best possible advantage.

2. *Shape and position of inserts.* There can be such an endless variety of shapes and positions of inserts that no set of rules can be made to fit all cases.

The determination of method of molding and the mold design itself must be predicated on a careful consideration of this point. A background of experience is essential to make these determinations if the shape or placement of inserts is intricate.

A molding procedure may be perfect to produce a certain piece—with one very small exception. The exception might be the impossibility of preventing insert carrier pin breakage for just one insert, or it might be a slight bending or shifting of one of the inserts. In cases of this sort the mold is a complete loss and failure unless supplementary means are adopted to circumvent the error.

3. *Size and position of small bore holes.* Much the same sort of examination and planning for inserts is also required to determine how to mold a piece with long small bore holes. In ordinary compression molding the plastic material is frequently moving and flowing under 3000 to 4000 lbs. per sq. in. pressure during the molding operation. This pressure times the projected area of unsupported core pin is a force with which to be reckoned. It should be given major consideration in determining whether the piece should be molded by compression or by other means.

If compression molding is decided upon, then the mold should be designed in such a way that the hazard of broken or bent core pins is reduced to a minimum. There are various ways to meet situations of this sort, e. g.: try to get customer to modify the design; introduce cores in the mold which will take the direct thrust of pressure from the moving material, and deflect the current from the core pin in question; mold as deep as possible from two opposite sides, and drill the rest after molding; provide the hole with a deep and large diameter counterbore (if customer will allow it); make the molding material flow in a direction parallel to the core pin axis.

4. *Consideration for life of, and upkeep expense of tools.* If large productions of any piece are contemplated—then this question of tool life and upkeep expense should be given careful attention. It can and should be one of the main points to be considered in determining what method of molding to adopt.

To the molder with a background of wide experience, who has been confronted with the problem of restoring worn-out tools for making millions more of a piece after the first million, this expression has a real significance. Errors in judgment can be packed with dynamite in the form of tool upkeep expense.

The intelligent purchasing agent will give this point consideration in deciding whether to place the business with the low or high tool charge bidder. (Much more can be written on this subject—but we are wandering far afield from the subject in hand; so, back to the "straight and narrow!")

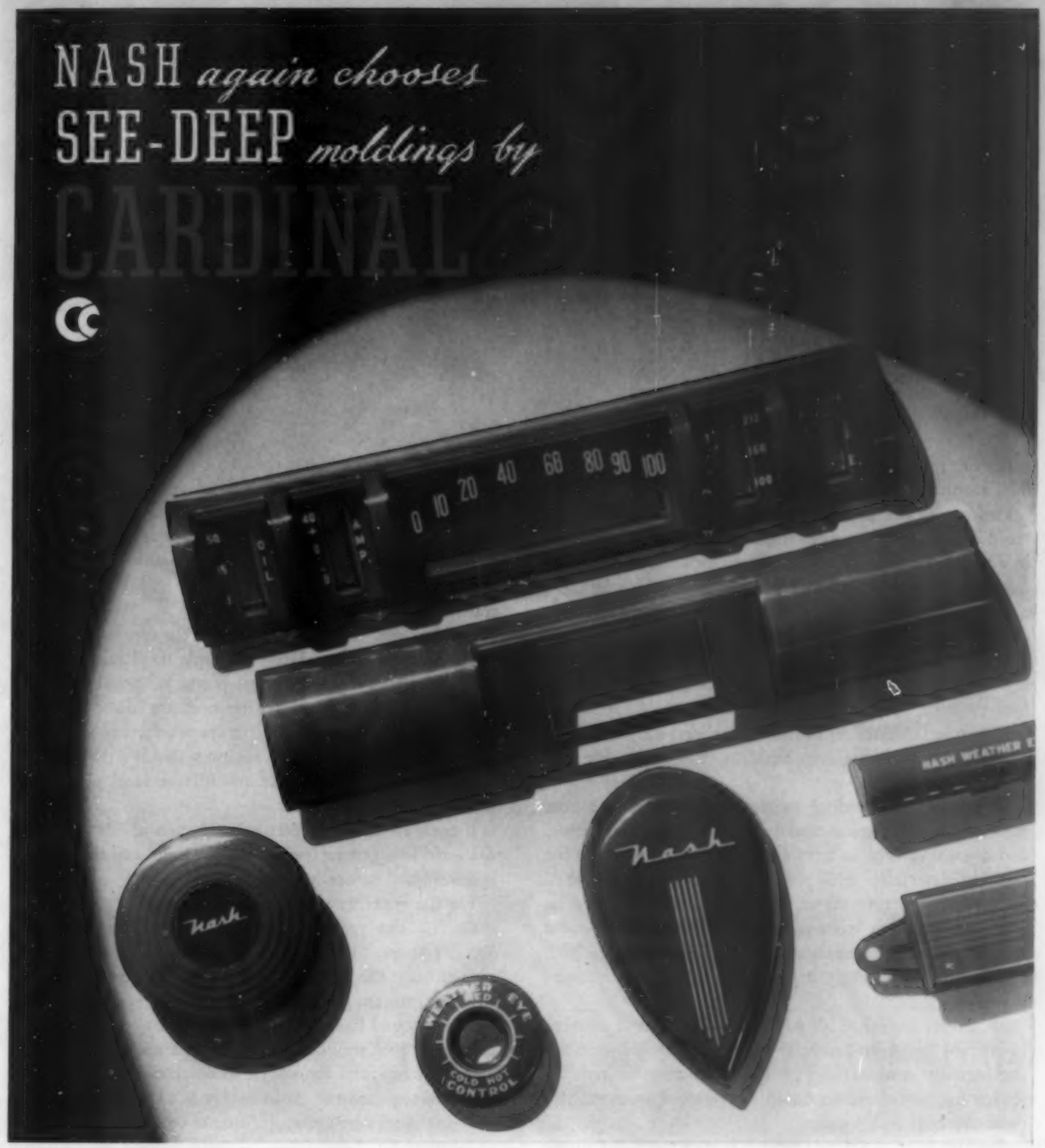
5. *Loading of mold.* In compression molding the charge of molding material is placed directly in the mold cavity. The charge may be in loose powder form, or in preforms of convenient size and shape. The lower cavity of a mold is seldom large enough to accommodate the charge and therefore additional "filling room" for the cavity must be provided.

There are various ways of providing this extra space; but the details belong more to the subject *Mold design* than to compression molding. It may be of interest, however, to merely list some of these ways.

1. Extension of maximum area of mold cavity to form deep "well" for filling. (Positive type mold.)
2. Extend a wall of steel upward around the outside edge of a positive land to form a "well." The positive land might be from $1/16$ in. to $1/2$ in. wide depending upon size and shape of cavity. (Positive land type mold.)
3. Disappearing type loading jacket.
4. Floating jacket type mold, which allows lower plunger to move downward, providing deeper filling well.
5. Removable loading jacket. (*Please turn to next page*)

A group of 600,000 lbs. capacity, hydraulic presses in the plant of Northern Industrial Chemical Co. The pipes, above and below, supply steam for heating the molds and platens and provide for its return to the power plant. They also provide compressed air for cleaning flash from molds

NASH *again chooses* SEE-DEEP *moldings by* CARDINAL



✻ **"SEE-DEEP," Cardinal's unique "three-dimensional" molding process, adds rich eye appeal to the smart interior of the new 1940 Nash. On the instrument panel and on the steering wheel, lustrous "See-Deep" moldings help to make the Nash a masterpiece of automotive designing. The Cardinal Corporation, Evansville, Indiana, molders of distinctive specialty-finished plastics.**

CARDINAL

Drill presses in the finishing department remove flash from molded holes, or drill holes in the molded part. Multiple drills are frequently used and jigs or guides assure accuracy in positioning throughout the production run

6. Stripper plate die—with stripper plate designed for "loading" as well as "stripping" purposes.

Preforming the molding material prior to loading the mold is a simple process of pressing the loose powder cold in a preforming mold. This is usually done in an automatic tablet machine. Both the single punch, and rotary (multiple punch) type of tablet machines are used for this purpose.

Materials of large bulk factor and "fluffy" type materials are difficult to preform because they will not feed through the hopper of automatic tablet machines. They can be tabletted by individual charge-weighing, and hand-loading the preform mold. This is a slow and expensive procedure.

Preheating of molding material is essential for best results in compression molding. Rotary-type heaters, and oven tray-type heaters are both successfully used for powder materials. Hot plates and oven trays are used for preheating preforms or tablets. In long steady runs of molded parts it is frequently possible to work out a relation between preheating time, and curing time which results in a surprisingly high production rate per cavity per hour.

6. Proper heating of all parts of mold. This is another important point to consider in any mold designed for compression molding. The two fundamental requirements for transforming molding powder into molded parts are heat and pressure.

Because heat is a fundamental requirement it follows that careful attention should be given this question of heat transfer to all parts of the mold. Almost any mold will become hot all over if given time enough, but the well planned molding method and mold will provide adequate and rapid heat to all parts of the mold.

Deep molds and molds with large diameter cores often present troublesome heating problems. These problems can be overcome in various ways but must be planned for in the original mold design. Electric cartridge heaters can be used in remote locations to supplement steam heating. In some cases induction heating may be used for cores. Rapid heat transfer can be made to pay dividends through fast production rate and low molding costs.

Different mediums are used to transfer heat from the source to the molding surfaces of compression molds, e. g.: steam, electricity, circulating hot water under pressure, circulating hot oil, and gas flame. Each medium has its proponents, but no opinion as to their relative merits will be ventured at this time on this controversial subject.

7. Pressure. This is the second of the two fundamental requirements. It is relatively simple to provide enough pressure per cavity, but some pieces of unusual design present filling problems which pressure alone will not solve. In certain shapes, air traps are formed which no amount of pressure within reason will fill with molding material. Enough pressure to collapse steel plungers is not sufficient in such cases.

If such air traps are recognized when molds are being designed it is generally easy to vent them and the trouble is eliminated before it starts.

For the general run of phenolic, and urea type molding materials the pressure required is from 2500 to 4000 lbs. per sq. in. Deep draw pieces may figure higher than this if only the projected area of the largest section is divided into the total pressure per cavity. This would not be a sound basis of figuring because no consideration is given the "area of draw" in such a calculation. A method frequently employed to determine the minimum pressure required per mold cavity is to use the formula: (Projected area by 2500) + (area of draw by 1000).

Pressure on the molding material during the molding operation can play all sorts of pranks on the mold designer in cases where extreme accuracy is required. Excessive molding pressure used in one way can reduce shrinkage—used in another it can increase shrinkage beyond normal. Varying pressure in the mold cavity resulting from unusual molded shapes has a marked effect on shrinkage. In one extreme case two sides of a square opening in a clock case shrank a normal amount, whereas the other two sides shrank 50 percent more than normal. Pressure was the explanation of this inconsistent shrinkage.

8. Elimination of gases. In compression molding this question is generally not given much consideration un-

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less pieces are to be molded from urea compounds. In case urea compounds are to be molded the mold should be designed so that it can be "puffed," or opened slightly to eliminate gases, without too much danger of tearing the partially molded piece, or disarranging inserts.

Trapped air, or gases generated during the molding process sometimes interfere with filling the mold cavity in remote corners. Venting such places or allowing an excess of molding material to run through these corners to an overflow pocket will overcome such difficulties.

9. Upward force of molding material during flow. When molding material in a mold cavity is being displaced by a plunger during compression molding, the upward thrust on the side walls of the cavity is a force to be reckoned with. If the side walls are integral with the bottom of the cavity there is no problem. If the side walls are formed by a jacket separate from the top and bottom plungers, then this upward force must be given consideration.

Unless this force is offset, the jacket may rise sufficiently to let the molding material out the "back door" before the cavity can be filled. This condition can be met by making a deep enough positive engagement between the jacket and lower plunger. There are also other methods of accomplishing this result.

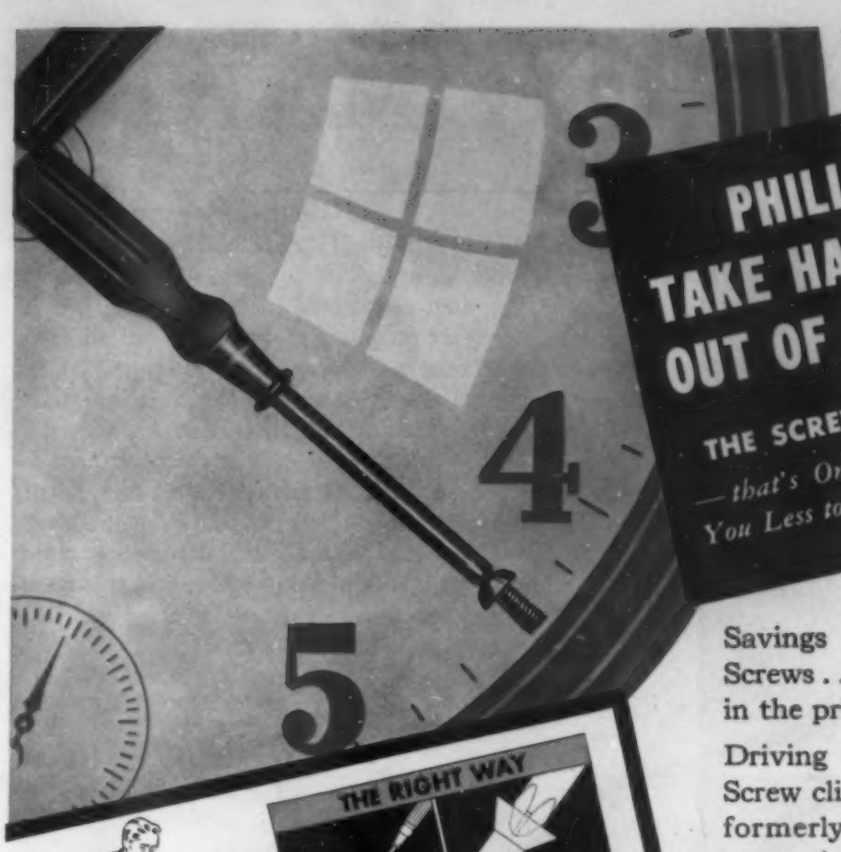
In split molds, where the split part is held together by means of side hydraulic cylinders, it is easy to overlook this question of upward pressure. If overlooked it is almost sure to rear its ugly head after the mold is made, and plague the designer. Here again it is easy to meet the condition and make provision for it by interlocking keys or some other suitable means if the need for it is recognized at the time the mold is originally designed.

10. Wedging action of long tapered plungers. If pieces with deep holes having a long gradual taper are to be produced by compression molding this wedging action should be studied. Consider for instance a deep lily shaped vase having facets on the outside, a flared-out circular base, and a gradually tapered deep hole for holding the water and flowers. Such an outside shape requires that the mold be split. The split halves must be held together by means of a solid jacket, or supplementary side hydraulic ram.

In a case of this sort it will be found that an enormous force will be required to keep the split halves together. The reason is that when the mold is nearly closed the wedging action of the tapered plunger against the nearly hard molding material creates an almost irresistible bursting force against the split halves. Unless a sufficient holding-together force is available, the designer would do well to consider methods other than compression molding to produce pieces of this shape.

To the layman who sees compression molding done for the first time, it looks very simple. He sees the mold cavity filled with powder or tablets, the mold closed under heat and pressure, the mold opened, and out comes the molded piece, finished except removing a few fins. What he doesn't see is the background of experience that is built into the mold. There is an expression "You can't play every instrument in the band," and this thought should be brought home to the man who decides to design and build his own mold to save money, unless he has had previous experience in designing molds for compression molding.

There are many hand-finishing operations in a shop that turns out a high quality product. Flash must be removed carefully by filing, especially on large molded pieces, as shown at lower right. Parts requiring a high polish are usually buffed on rag or felt wheels as shown below at the left. This work is done by skilled craftsmen and craftswomen who can spot a flaw a mile away



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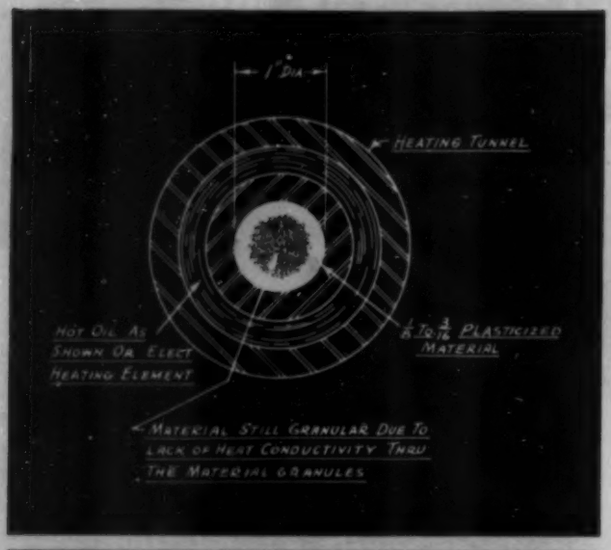
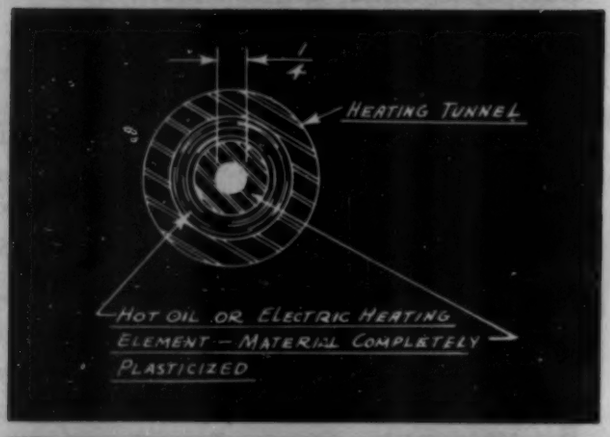
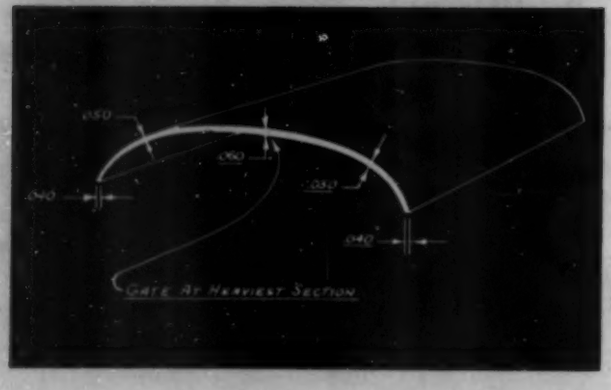
INJECTION MOLDING

by L. T. BARNETTE*


1" DIA.
HEATING TUNNEL
HOT OIL AS SHOWN OR ELECT HEATING ELEMENT
PLASTICIZED MATERIAL
MATERIAL STILL GRANULAR DUE TO LACK OF HEAT CONDUCTIVITY THRU THE MATERIAL GRANULES





The two upper diagrams indicate the method by which thermoplastics are plasticized in the heating tunnel of an injection molding machine. Note comparison of plasticization between large and small aperture. The lower diagram indicates proper mold construction to eliminate gas or air pocketing

SINCE THE FIRST INJECTION MOLDING MACHINE was imported into the United States in 1934, much progress has been made in this molding art. We refer to it as an art because although there are probably somewhat over 600 machines in operation in the United States today, there are still many problems to be worked out both from an equipment and method standpoint. In other words, injection molding has not yet been reduced to a science and until this time is reached, results must be secured by more or less cut and dry methods subject to the judgment of the individual designers or molders. Like many other fabricating operations, it is necessary to control the forces of nature involved and inasmuch as there are principally five variables to be considered the different combinations of these variables are practically unlimited.

The five variables referred to are as follows:

1—Materials feed.
2—Temperature of materials.
3—Injection pressure.
4—Clamp pressure.
5—Mold temperatures.

Materials feed

1. The quantity of materials fed into the heating cylinder is important despite the automatic equipment available to date. For example, when injecting one ounce of material per shot, the most ideal situation would be to feed one ounce of material into the heating cylinder for each movement of the injection piston. This insures a continuous uniform flow of material through the heating cylinder and enables more rapid cycles without the danger of overheating or burning the material. In other words, such an accurate and uniform condition permits higher temperatures on the material and more rapid plasticizing than an irregular or spasmodic feed. The faster the material is forced through the heating tunnel, the higher the temperature must be in the heating cylinder. For example, in our plant we have a 2-oz. per min. rated machine from which we can mold better than 7 oz. per min. in shots of $1^{25}/_{32}$ oz. each, four shots per minute. This is accomplished by a very fine adjustment on the automatic feed which enables us to run at a higher temperature and thereby secure complete plasticization of the materials without burning; also die temperatures automatically controlled assist greatly to maintain this rapid cycle.

Materials temperature

2. Practically all of the materials in the thermoplastic group are poor heat conductors. Consequently, there is a limit to the section or thickness of the com-

* Thermo-Plastics, Inc.

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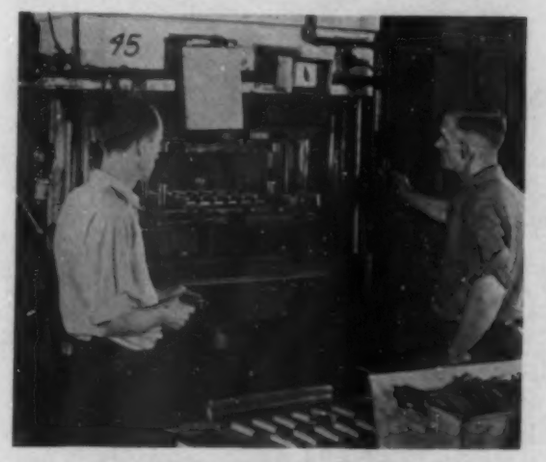

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Interior of car equipped with dash panels molded on multiple-unit injection machine. Metal inlays and name plate are applied after the molding is complete

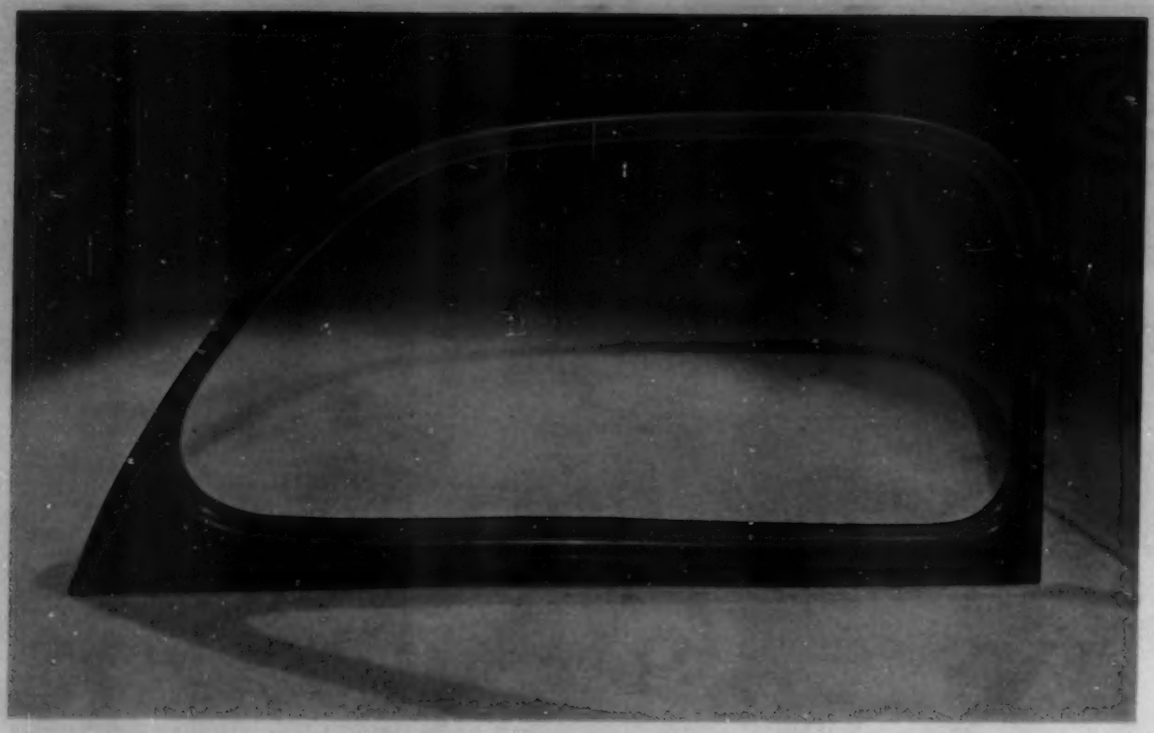
Close-up of the dash panels in which the base is a .040 in. steel stamping, 7 in. by 16 in. long. Over the entire surface a .050 in. coating of cellulose acetate is injection molded, anchored around the edge

pressed granules which can be properly plasticized. In our experience, cellulose acetate can be readily and quickly plasticized in a heated round section of $^1/_4$ in. diameter. On the other hand, some standard equipment on the market today contemplates a $^7/_8$ in. cross-section of material in the heating tunnel in which case the materials are heated from both sides. Unfortunately, no one yet knows how many calories of heat it takes to plasticize a cubic inch of a given formula of acetate materials. Consequently, the usual procedure of the machine manufacturer is to try out experimental heating tunnels under various conditions in order to determine their capacities. To play on the safe side, the equipment is usually rated with an ample safety margin below the maximum results secured. This procedure is also deemed necessary from the standpoint of average molded parts. Obviously, materials injected into a simple mold wherein a minimum number of material flow turns is necessary will require a lower capacity heating tunnel than a complicated die with many material flow turns and sub-cavities to be filled. Recently in one experiment we learned that an 8-cavity die—the molded shot from which, including gates and sprues, weighed somewhat over 8 oz.—had been run on a 7-oz. machine at the rate of one shot each $1^1/_2$ minutes. These 8 molded pieces were not uniform, shrinkage being prevalent in some of them and occasionally the cavities did not completely fill. By blocking off 4 cavities of this mold and running it on the same machine, 3 shots—or 12 good pieces per minute—were satisfactorily molded. We have therefore concluded that when there are no cooling problems involved, dies should be so designed as far as the number of cavities is concerned so that somewhere between 50 percent or 60 percent of the total tunnel capacity is utilized. Great difficulty has been experienced in designing satisfactory heating tunnels so that the material does not become trapped and burned, thereby necessitating a cleaning operation. Inasmuch as this particular difficulty represents one of the most serious problems now present in the prevailing standard machines, we predict that the most progress in improvements for some time to come will be along this line. *(Please turn to next page)*

Only in appearance are plastic molded displays expensive—actually they usually cost less than those made of other less attractive materials, and they are always far more economical, for they do a better job of merchandising. If you want your product *on* the dealer's counter instead of *under* it—furnish the dealer with an attractive plastic molded counter display. Our merchandising, design and engineering staffs are ready to cooperate upon request.

CHICAGO MOLDED PRODUCTS CORP.

1046 North Kolmar Ave. **Chicago, Illinois**



Above—Automobile window garnish molding experimentally produced by Thermo-Plastics, Inc., on a four-unit machine without showing weld marks. Below—24 powder can closures injection molded of Tenite at a single shot by Bridgeport Moulded Products, Incorporated

Injection pressure

3. Injection pressures on the materials are important. Naturally, the speed of the production cycle is dependent on how cool, comparatively, you can run the molds. The faster you can fill the cavity or cavities *satisfactorily*, the colder the molds can be run and the more rapid cycles can be maintained. The mold design is also important from the standpoint of injection speeds since it is necessary for the incoming material to force out the expanding air in the cavities displaced by it as well as any gas which is usually prevalent. Theoretically, the quicker a die can be filled, the better; but there is apparently a limit for the various design pieces to be molded based on the dies, venting, cooling, etc. Some research work is now being performed on the vacuum principle for die cavities. This may assist in working with lower material pressures, but we confidently believe that the trend to higher pressures and faster piston speeds on the materials will be prevalent through future developments. Very often in filling the cavities too rapidly, the expanding air and gas is trapped at some point in the cavity where it cannot escape. In certain instances, under these circumstances, such air and gas is compressed to a point where it actually explodes, similar to Diesel action, forming a small burnt spot in the material. To overcome such a situation without venting in the cavity itself, the design of the cavities should be such that they fill farthest from the parting line first,

is just another way of saying—

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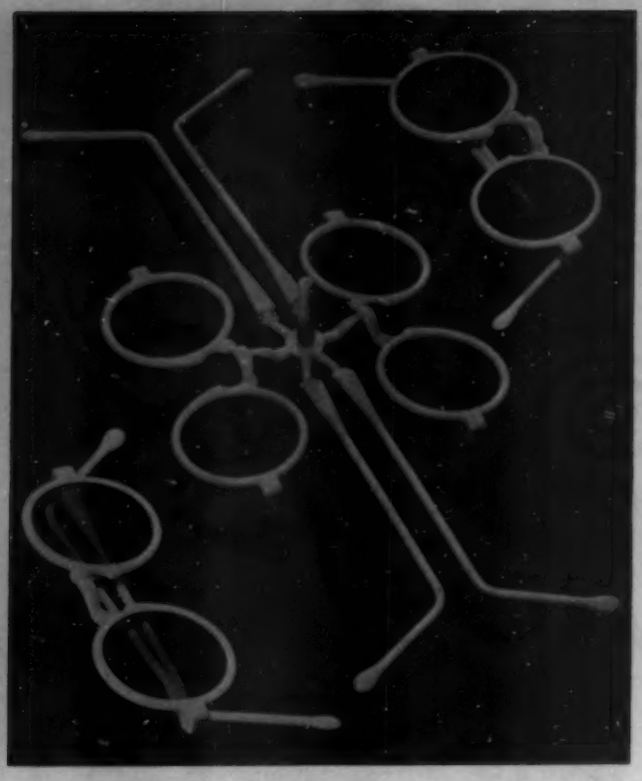
ARTISTS OF PLASTIC MOLDING

IT'S hard to say just what makes one molded product stand out among all the rest . . . but you can always be sure it *will* . . . if it is *molded by COLT*. Our experience, our equipment, our personnel all contribute to a molding service second to none . . . whether the job is a big one or a small one. Our designing facilities assure smartness, adaptability and eye appeal. The eyes of the molding industry have always been on Colt . . . pioneers of what is new, beautiful and practical in molded products.

Tell us about your molding problems. We will work with you as part of your own organization. We can serve you as we have hundreds of organizations, large and small.

PLASTICS DIVISION
COLT'S PATENT FIRE ARMS MFG. CO.
HARTFORD, CONN.



Hack saw handles of Tenite are molded three at a time. The two halves, cemented together over a metal shank, provide a handle that is firm, easy to grip, and practically unbreakable. Molded by Columbus Plastic Products Co. for Forsberg Mfg. Co. Sun glass frames at the right are molded of the same material by Spill Mfg. Company

thus permitting the material to flow out to the parting line last, slowly and surely dissipating such air and gas.

Clamp pressure

4. Clamp pressures on the dies must be sufficient to eliminate flashing during the molding operation. Such pressures should be so regulated and controlled that the mold will close quickly but will not be bumped or pounded as the halves or parts actually come together. There are many theories as to the amount of clamp pressures required by injection. When first introduced, it was estimated that, based on the projected cavity area, a clamp pressure of approximately 9 tons per sq. in. was required. While it is always safe to figure in such a manner on the larger parts, the equipment for such pressures would be prohibitively large and expensive comparatively. Again, a great deal seems to depend not only on the size and shape of the part but also on the design of the molds. Our experience, especially on the larger parts, indicates that clamp pressures of from 3 to $3^1/_8$ tons per sq. in. of projected cavity area are sufficient.

Mold temperature

5. Mold temperatures should be held constant in order to secure not only the best but uniform molding results. Inasmuch as the finished side of a part can be molded with a higher luster and greater smoothness by the use of higher temperature, it is very often desirable to run this side of the die somewhat warmer than the opposite or unfinish side. In our estimation, it is just as important to control the mold temperatures as accurately as possible as any of the other variables present in injection. Our machines are so equipped now experimentally, and we hope to have practicable methods worked out to a satisfactory conclusion soon. Mold temperature controls are becoming more important also from the standpoint of new materials and new formulas for the present materials which must be injected into dies heated to a higher temperature than the hot materials will maintain. In such cases the production cycle is not always affected as the pieces can usually be ejected from the mold at a somewhat higher mold temperature than it is found necessary to maintain.

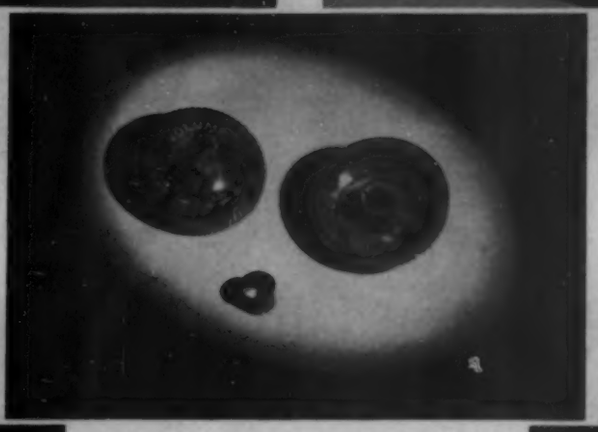
Injection molding has taken its place in industry and while progress has been necessarily slow due to the many variables involved, there are so many economies available by this molding method that we predict it will soon be placed on a strictly scientific basis. Furthermore, we understand that it is now possible to injection mold some of the thermosetting materials in small parts. When and if this development is completed and larger parts can be so molded, the compression method will have to be speeded up and progress in proportion, if it is to successfully compete with injection methods.

ERIE INJECTION MOLDED PLASTICS

Fulfill Expectations as well as Specifications

Housewives are attracted by the unusual beauty and depth of color of this Crosley Refrigerator cold control.

Erie originated and perfected injection molding of plastic bezels around plate or spherical glass in one operation.



Split hub construction simplifies installation of this radio volume control knob, injection molded for the Colonial Radio Corporation.

These are the first television coil forms molded on a production basis. Used in RCA Victor Television sets, these important parts required high calibre workmanship.

A small design change, suggested by Erie molding engineers, stepped up production of the Lovell Clothes Wringer pressure control part, shown at the right, 200%.

When you write the specifications for your molded parts you have certain definite expectations that you want fulfilled. Unfortunately, in many cases it's possible to meet every one of your written requirements, yet the finished product may not quite measure up to your preconceived ideas.

Here at Erie Resistor, you will find all the necessary mechanical equipment required to produce good, first-class injection molded jobs. In addition, there are engineers and production men that have grown up with injection molding. They know all the "tricks of the trade," and from past experience can take full advantage of the many opportunities offered by this method of molding. These men, in designing and supervising the construction of dies, selecting the proper molding material, setting up the dies for actual operation, finishing and inspecting the completed pieces, make the difference between an outstanding job and one that merely meets specifications.

The illustrations at the top of the page are a few examples of Erie "plus values" that have been injection molded into a variety of products for customers all over the country. May we show you what we can do for you?

ERIE RESISTOR CORP.— *PLASTICS DIVISION*

640 W. 12TH ST., ERIE, PA.

The back of the Polaroid desk lamp, the hack saw handle, and the handle for the coffee maker shown here were all transfer molded by Northern Industrial Chemical Company

TRANSFER MOLDING

by FRANK H. SHAW*

ALTHOUGH MANY ARTICLES HAVE BEEN WRITten on the subject of transfer molding—what it is, how it is accomplished and its advantages—the marked increase of interest in this method of molding during recent months would seem to indicate that there are many manufacturers and perhaps some molders who are just beginning to appreciate the outstanding results which have been and can be obtained by the employment of this method of molding thermosetting materials.

The term *Transfer Molding* is used to identify a method and apparatus for molding thermosetting materials whereby the material is subjected to heat and pressure and then forced into a closed mold cavity. It has been said that the process is similar to the die casting of metals and to the injection molding of thermoplastics. This is true but only to a very limited extent. Transfer molding was first conceived a very long time after metals were die cast and after Hyatt's disclosure of injection molding. Even after the important discovery that thermosetting materials could be reacted and molded in dies by heat and pressure, a surprisingly long period passed before the advent of transfer molding. Thus, history indicates that there is something different about the technique and that it involved the solution of problems not present in and not answered by other methods of molding. Transfer molding stands out sharply in contrast with metal die casting and injection of thermoplastic materials principally because it concerns the molding of potentially reactive infusibly thermosetting resinous material as distinguished from metals and thermoplastics which can, at any time, be melted or softened by heat and are hardened by cooling.

Therefore, in so far as this method of molding may fairly be compared to any other molding method, it is comparable only to compression molding in which the mold is open when it is charged and pressure is applied to the charge by the closing of the mold and following which the heated mold brings about the thermal reaction of the heat-hardening material. But before making such a comparison here, the operations of transfer molding will be described in more detail.

Transfer molding has been practiced in various ways with widely varying forms of apparatus. The first step is to introduce the molding compound in desired condition into a loading chamber or cavity which communicates through a passage or passages with the cavity or cavities forming the finished articles. The charge being

* President, Shaw Insulator Co.

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add Beauty . . Convenience and Production Savings to . . .

New HAMILTON BEACH *Products . .*

NEW HAMILTON-BEACH FRUIT JUICE EXTRACTOR

NEW HAMILTON-BEACH FOOD MIXER

Typical of many famous manufacturers using Eclipse Precision-Moulded Plastics, Hamilton Beach Mfg. Company, Racine, Wisconsin, enjoyed several advantages in the design and production of their new Food Mixer and Fruit Juice Extractor. The modern streamlined Eclipse-moulded Plastic Handle on the Mixer was carefully balanced for easier handling, and accurately finished to permit a new single-bolt assembly saving one important labor operation.

Strength, light weight, easy cleaning and new convenience were achieved in the Plastic Extractor Funnel, and Plastic Drip Cup. Accurate, close fit of the new design Drip Cup prevents splashing, dripping. Mounted on a special swivel arm, the new cup automatically swings back into place after juice is transferred to a glass.

These are only two examples of the versatility and accuracy of Eclipse Moulded Plastics. Let us show you how you, too, may benefit by our thorough knowledge of Plastic Materials and their application to all industries.

Important . . .

Call upon ECLIPSE for an UNBIASED recommendation. Eclipse Designers, Engineers, Craftsmen are trained in moulding ALL PLASTICS. They know which of the many available modern plastic materials will most profitably serve your needs. Send blueprints or write for salesman to call.

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MOULDED PRODUCTS COMPANY

MILWAUKEE WISCONSIN

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MOULDERS OF . . .

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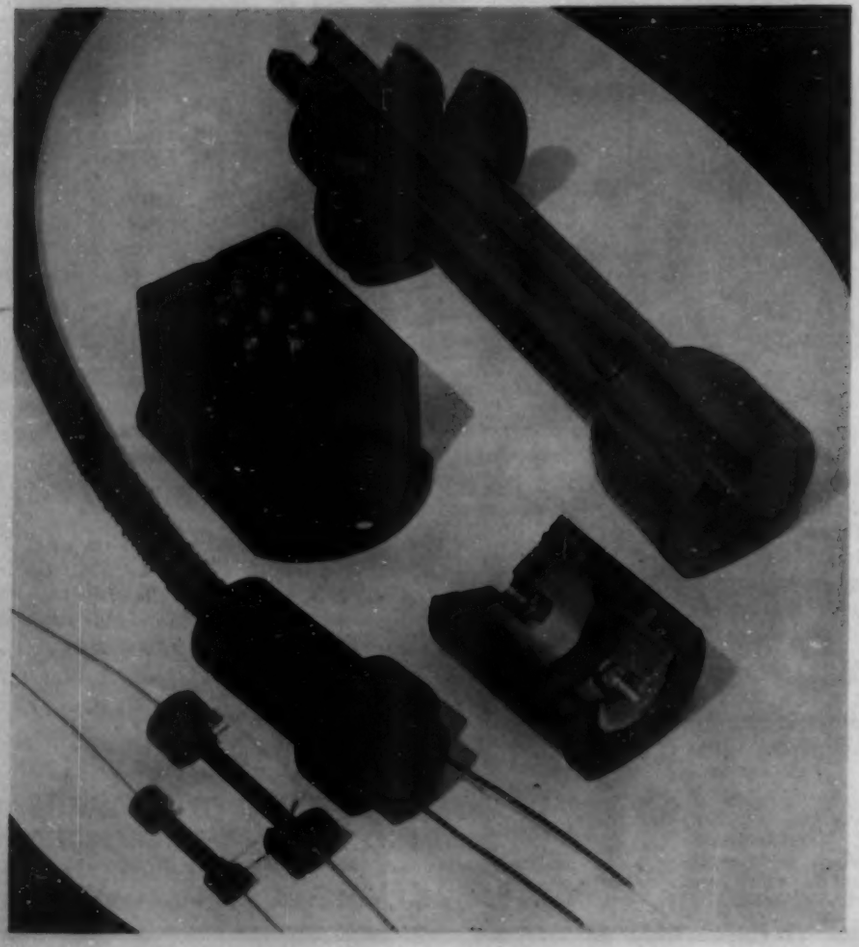
heated and subjected to pressure softens sufficiently to cause it to flow into the cavities under the pressure of a piston or force plug which fits into the charging chamber. Further heating may take place as the material flows through the narrow passage and in some cases practically to the temperature of reaction so that the period of curing in the die may be shortened. After the die is filled, application of pressure may or may not be continued while the heated die completes the reaction in the material. When sufficiently cured the molded articles are removed.

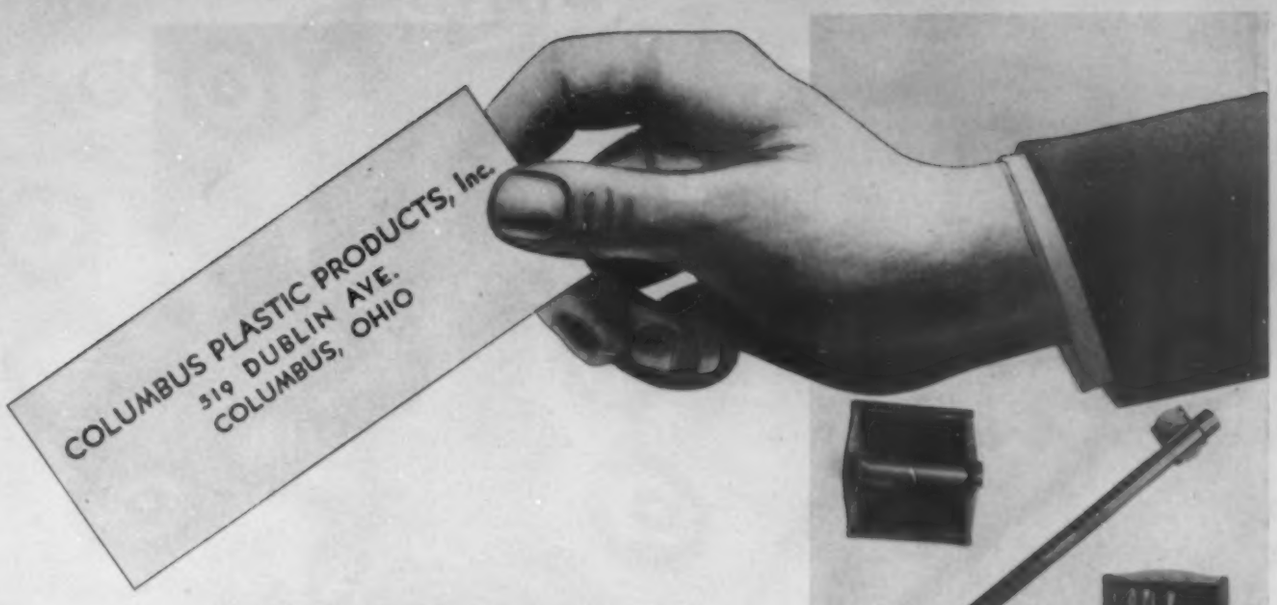
The principal problem solved by transfer molding is the prevention of clogging in the narrow passage connecting the loading chamber and the die cavity caused by the hardening or curing of material in such passage. In other words, it is essential that the apparatus be cleared of all set material in order to permit repetition of the molding cycle. One method of clearing the apparatus,[1] in which a separate charge including an excess of material is supplied to the loading chamber in each cycle, is to permit the excess of material remaining partly in the loading chamber and partly in the passages, to harden and form "cull." This cull is removed after each molding operation, the removal of the material in the passages between die and loading chamber being facilitated by tapering the passages toward the die so that breakage will occur near the molded piece where the passage material is of smallest cross section.

If it is desired to employ transfer molding without forming cull in the loading chamber, then the operation must be so controlled as to prevent any material remaining in the loading chamber from hardening therein and reacted material in the passage or passages must be removed by providing for a break-off in the passage for removal with the molded piece, leaving in the passage, material which can be discharged therefrom in a succeeding operation.[2] Reacted passage material may be removed with the molded piece. This mode of operation permits unreacted or partly reacted material remaining in the loading chamber and in the passage to be delivered to the die in a succeeding molding cycle. The formation of cull in the loading chamber may also be prevented by completely emptying the chamber in each molding cycle before the charge has an opportunity to set or harden.[3] In this case the set passage material also may be removed with the molded piece.

By proper design of molds appropriate to the articles to be produced, including proper venting of the molds, and selection of suitable types of molding compounds, the desired flow of material is obtained and premature hardening avoided, especially in long narrow passages in the dies. Considerable transfer molding technique



The long piece at the top shows a cross section of molded fuse indicator barrel with molded threads near the center. Next below at left is a terminal connector box with seven delicate metal inserts molded in place. At the right is a sectional view of a molded tube closed at each end with threaded brass plates which are anchored in the piece. This shows the possibilities of hollow design available through transfer molding. The large piece with protruding wires is a detonator connector compositely molded of rubber and cotton-covered wire with Bakelite laminated insulator surrounded by molded Bakelite. The two lower pieces are coil forms with delicate wire terminals. All molded by Shaw Insulator Company



ASK US IN

to assist you in Plastic Planning

Perhaps you have some article in mind which you feel may be made more attractive and more economical in plastics. If you have, and will supply us with specifications, our experienced product designing and engineering department will be glad to study the problem and submit their recommendations.

In that way a large Eastern saw manufacturer found that we could supply saw handles in plastics which are more attractive, durable and economical than the type of handles previously used. So also, to mention only a few, an instrument manufacturer converted his metal casings to plastics, a bathroom fixture producer changed his line to plastics. In ever-increasing numbers manufacturers are finding these molded materials to be a decided step to more profitable production. With our ever-expanding group of satisfied clients, Columbus Plastic Products, Inc., is proud to be a part of that forward march of progress.

Our well-equipped, well-manned plant can efficiently handle injection molding of cellulose acetates, polystyrene, butyrate, and other thermo-plastic materials.

All inquiries will be promptly and thoroughly answered

COLUMBUS PLASTIC PRODUCTS, INC.

519 DUBLIN AVE. COLUMBUS, OHIO

Transfer molded terminal bases of complicated design with inserts accurately placed in the molded part. The sprue, showing where the compound entered the mold, may be seen still attached to the right-hand piece. Molded by Shaw Insulator Company

is involved in molding certain shapes and sizes of articles while production of other articles offers no difficulties.

The various advantages of transfer molding have previously been described in detail and will only be summarized here. First, the process offers an ideal method for preheating thermosetting compounds. A relatively high temperature may be applied to the compound in the loading chamber and by using gates and runners of relatively small cross-sectional area, preheating to a relatively high temperature and uniform preheating may be assured. The compound is delivered to the mold in such plastic condition that surging, erosion of dies and displacement of and damage to inserts, so common in compression molding, can be prevented and savings of inserts and reduction of rejects may be effected. This permits the molding of intricate shapes and articles accurate to .001 of an inch.

Transfer molding is of particular advantage in molding articles requiring inserts or cores of such character or arrangement that molding of such articles by compression molding is impossible or is too expensive because of a high proportion of rejects. Moldings with glass and ceramic inserts can be produced successfully. Very small cores or pins can be employed for forming extremely small holes in articles which is especially advantageous with articles too delicate to permit drilling. Higher and more uniform density may be obtained with this process, at least in molding some types of articles, than can be obtained in compression molding. Separation of resin from the filler is minimized by transfer molding.

Some types of compounds which give difficulty in compression molding can best be shaped by transfer molding. An example is impact material, types of which cannot be preformed satisfactorily for compression molding and leave a heavy flash which entail substantial finishing costs in compression moldings but which, in this method, usually give at most a thin film of resin which can easily and cheaply be removed. High mold costs due to high bulk factor of impact material in compression molding are greatly reduced if not eliminated by transfer molding. Impact material can be molded in much thinner sections by transfer molding than by compression molding.

Even with ordinary compounds, such as those with woodflour fillers, it is sometimes advantageous to employ the transfer method in preference to compression molding because of the higher and more uniform density and freedom from gas pockets which can be obtained with resulting increase in strength in the molded articles, and this without having to open the mold for breathing because of the escape of gases and vapors from the loading chamber and die. This is significant because it indicates a probable expansion of the field for this type of molding at least for certain types of articles.

1. U. S. Patents Nos. 1,916,495 and 1,919,534 assigned to Shaw Insulator Co.
2. U. S. Patent No. 1,933,942 to Novotny and assigned to Shaw Insulator Co.
3. U. S. Patent No. 1,997,074 to Novotny and assigned to Shaw Insulator Co.

31 Years of ACCOMPLISHMENT

The items shown here are typical — the Spinning reel, chemical resistant; the Chiclet counter case — outstanding merchandise display; the telephone — metal inserts and a hollow brass tube accurately and permanently imbedded, an example of Transfer* molding as is also the electrical distributor.

By *doing* we proved theory in practice — by *doing* for thirty-one years, starting as pioneers in the molded plastic industry, we have met and solved, through our own experience and research, problem after problem. That process is still going on and we invite problems — your problems. With a record of *doing* the difficult thing well — with outstanding success in creating molded plastics to fit a purpose — to solve a problem in precision, uniformity, design, economy, beauty or utility — we offer experienced cooperation.

*Licensed under Shaw Patents for Transfer Molding.

NORTHERN INDUSTRIAL CHEMICAL CO. · *Specialists in Plastics* · **11 ELKINS ST., So. BOSTON, MASS.**

Northern

RESIN BOARDS AND BLANKS

by R. E. BRANNAN*

SEVERAL YEARS AGO THE IDEA OF PRODUCING a molding stock by the paper mill process, and incorporating phenolic resin in the pulp during its manufacture, was conceived. Like any new development, there were numerous details to be worked out, both in the process and in the finished material. After several years of research and experimentation with the problem of producing a thin sheet of paper by the regular paper mill process, it was decided to experiment with a different method, which would give a different product.

This method, which in paper mill parlance is known as "wet machine" manufacture, produces a pulp board of any desired thickness. During the process of making the board, the resin becomes thoroughly dispersed throughout the pulp in the beater. The resin board may be supplied in either sheets or punchings and can be employed alone or in conjunction with phenolic molding powders.

Properties

The following are the general properties of resin board:

Physical (Molded):

Specific Gravity 1.35, Weight per cu. in. 22.2 gms.
Tensile Strength 3000 to 11,000 lbs. per sq. in.
Modulus of Elasticity (1.1 to 1.6) by 10^6 lbs. per sq. in.
Impact Strength—Energy to break with grain 0.8 to 1.0; across grain 0.3 to 0.45 ft. lbs.
Impact Strength ft. lbs.—per inch of notch = twice energy to break
Impact Strength—Ft. lbs. per inch square—with grain 10.0 to 12.5; across grain 3.7 to 5.6
Molding Shrinkage .002 to .005 in. per in. (less shrinkage with grain than across grain)
Flexural Strength 13,000 to 25,000 lbs. per sq. in.
Water Absorption Gain in 24 hrs. 0.3 to 0.5 percent
Heat Resistance—Not recommended for use where molded parts are to be subjected to temperatures higher than 302 deg. F. (150 deg. C.)

Electrical (Molded):

Dielectric Strength at 60 cycles—instantaneous 240 volts per mil.
Material not regularly controlled for electrical properties.

Fabricating (Raw Material):

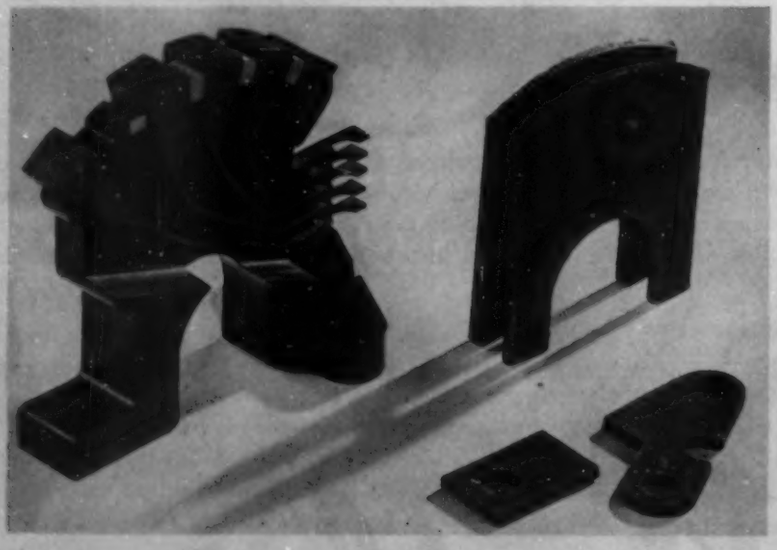
Sheets—when specifying size, grain direction is parallel to second dimension.

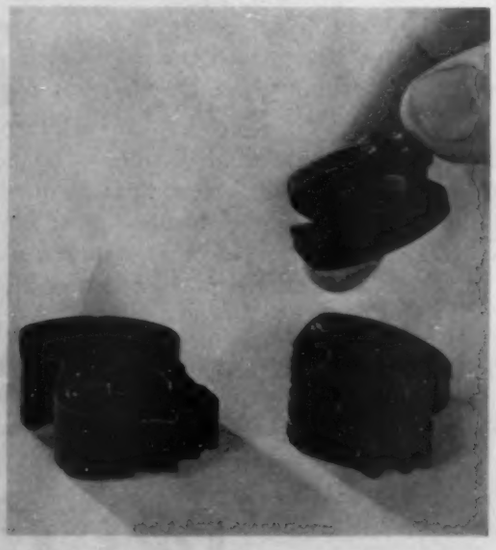
To produce standard molded thickness	Weight per sheet 48 in. by 66 in.	Weight per square inch
.031 in.	5.05 pounds	.72 grams
.062	10.1	1.45
.093	15.2	2.18
.109	17.8	2.55
.125	20.4	2.92

Blanks—to order in all thicknesses
Bulk factor—1.5 to 1 (*Please turn to next page*)

*Sales Engineer, Bakelite Corp.

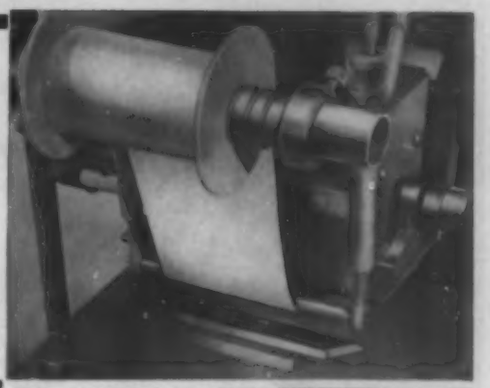
Thirteen resin blanks, weighing 84 1/2 grams, and 175 grams of Bakelite molding material are used to form this controller switch at the left. Bosses, on the resin blanks at extreme right, make it easy to assemble the blanks before pressing into one unit for production of a molded refrigerator door latch. The completed part is shown at the left of the smaller photograph





THE PROCESS YOU WILL ADOPT EVENTUALLY

THE PEERLESS PROCESS
of Marking and Decorating Plastics



AS EASY AND ECONOMICAL AS PRINTING is the Peerless Process of marking plastics. Your operator feeds the article to be stamped under the head of a Peerless Stamping Press fitted with a brass or steel die (or type) and a roll of Peerless Stamping Foil. With each operation of the press the design is engraved into the surface of the plastic and the color transferred at the same time.

A WIDE RANGE OF COLORS INCLUDING BLACK, WHITE, GOLD, AND SILVER are available. The new Peerless Colors, shown in the Peerless Color Chart, harmonize with the new plastic colors, making it possible to secure an unlimited number of color effects. With the Peerless Process no drying time is required. Painting in and wiping off operations are eliminated.

IMPRESSIONS LOOK AS THOUGH MOULDED IN OR ENGRAVED. The impressions are deep and clean-cut. The colors are lustrous and durable. The results are directly comparable to those obtained by present, more costly methods. Ask for a sample of plastic material stamped by the Peerless Process. Better yet, send samples of your plastic materials to be stamped and returned to you.

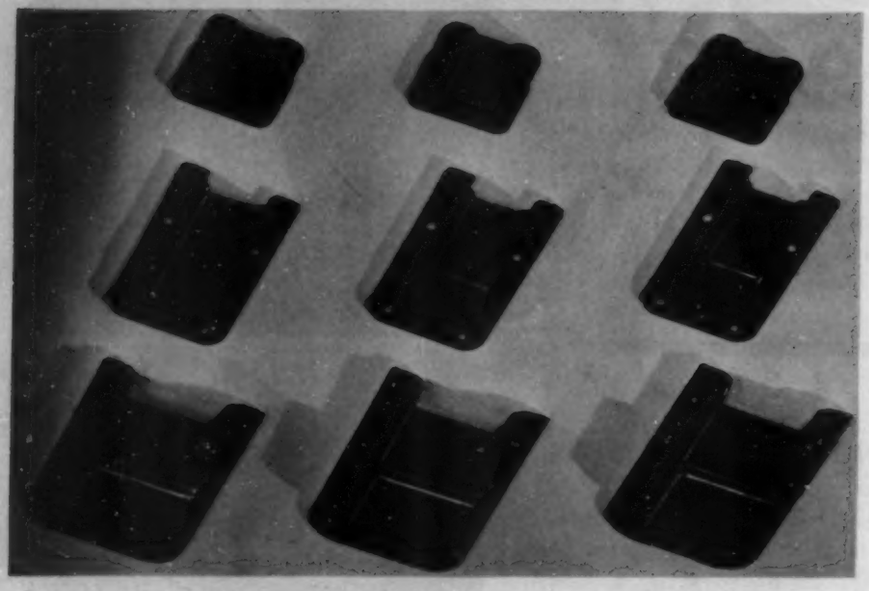
PEERLESS ROLL LEAF CO., INC.

913 NEW YORK AVENUE

UNION CITY, NEW JERSEY

BRANCH OFFICES IN CHICAGO, BOSTON AND LONDON

To produce a tough housing for an arc suppressor, resin blanks are combined with a thin strip of fiber and molded. Then, two pieces are riveted together to form the housing



Shock-resisting refrigerator handles are made by molding with a resin blank insert. The insert and a completely molded handle appear at the left

Stock dies:

Disks—1/4 in. diameter to 5 in. diameter, at 1/16 in. diameter increments

Rings—1/2 in. outside diameter to 4 1/2 in. outside diameter by 1/4 in. inside diameter to 4 1/4 in. inside diameter, at 1/16 in. diameter increments. Outside diameter minus inside diameter is not to be less than 1/4 inch.

Small rectangles and squares—either dimension 1/4 in. to 12 in. in 1/8 in. increments. Dies for special shapes built on demand at customer's expense.

Uses

Most of the early applications of the resin board for molding purposes were as reinforcings around lugs and special sections of molded pieces that required extra impact strength.[1] Uses of the material have been growing rapidly within the past year. Where at first the resin blanks, punched from board stock, were employed in combination with molding powders, later developments indicated that the board can be used alone for complete moldings. For example, it is not outside the realm of possibility that this product may be used independently in the future to produce doors for automobiles and refrigerators. There are also indications that the material will find wide use in the field of structural building and machine design, where toughness and ease of molding the board will enable the designing engineers to accomplish better results with less weight and greater rigidity.

Among the newer applications for resin blanks is a controller switch manufactured by the Automatic Transportation Co. The molded part for this switch required five inserts with leads going through the entire assembly. Electrical insulating properties and strength were prime requisites in the finished part. These were accomplished by using thirteen resin blanks, weighing 84 1/2 grams in combination with 173 grams of molding material. The molded pieces have not only proved strong, but exceptionally serviceable.

Another interesting application for resin board may be found in its use on refrigerator door latches. The Winters and Crampton Corp. has taken advantage of this material and make, its latch of three resin board blanks. As the blanks are made, a boss is raised on one side of the resin board with a corresponding depression on the other side. By telescoping the bosses into the depressions, it is possible to assemble these three blanks into a unit, thus making the mold loading operation quick and easy. These parts, produced from molding board, withstand

[1] Modern Plastics, October 1936, page 198.

MOLDERS in *ALL* PLASTIC MATERIALS

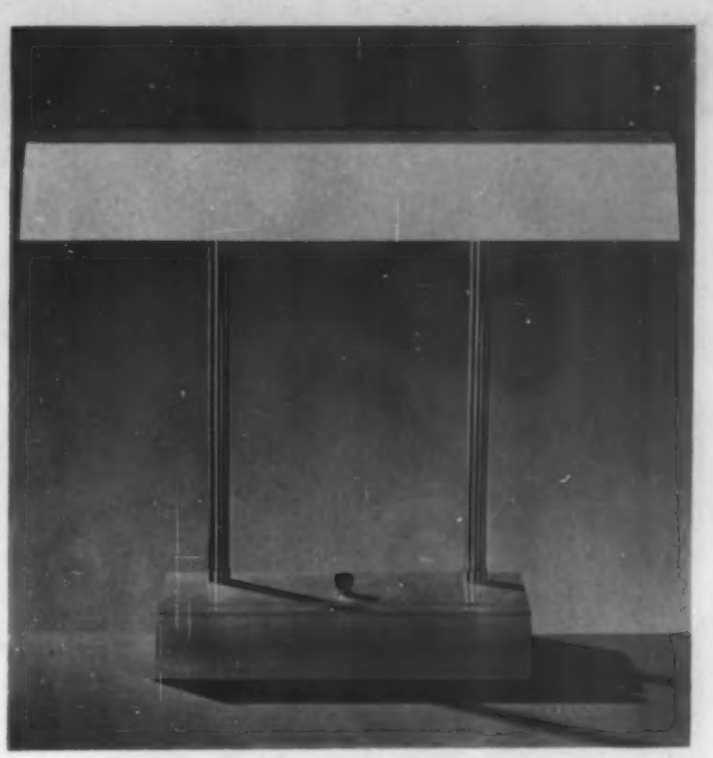
To replace copper, steel, expensive finishing costs you should—now and without delay—consider plastics for your products.

There are five different types of plastics and each of these offers its own unique and valuable properties—but each in turn requires its own skilled molding technique.

Universal has mastered the art of molding these various resins. This expert knowledge is at your disposal.

With hydraulic presses up to 500 tons compression, and injection presses up to 6 ounces capacity, our new and greatly enlarged plant offers the latest facilities for every class of molding.

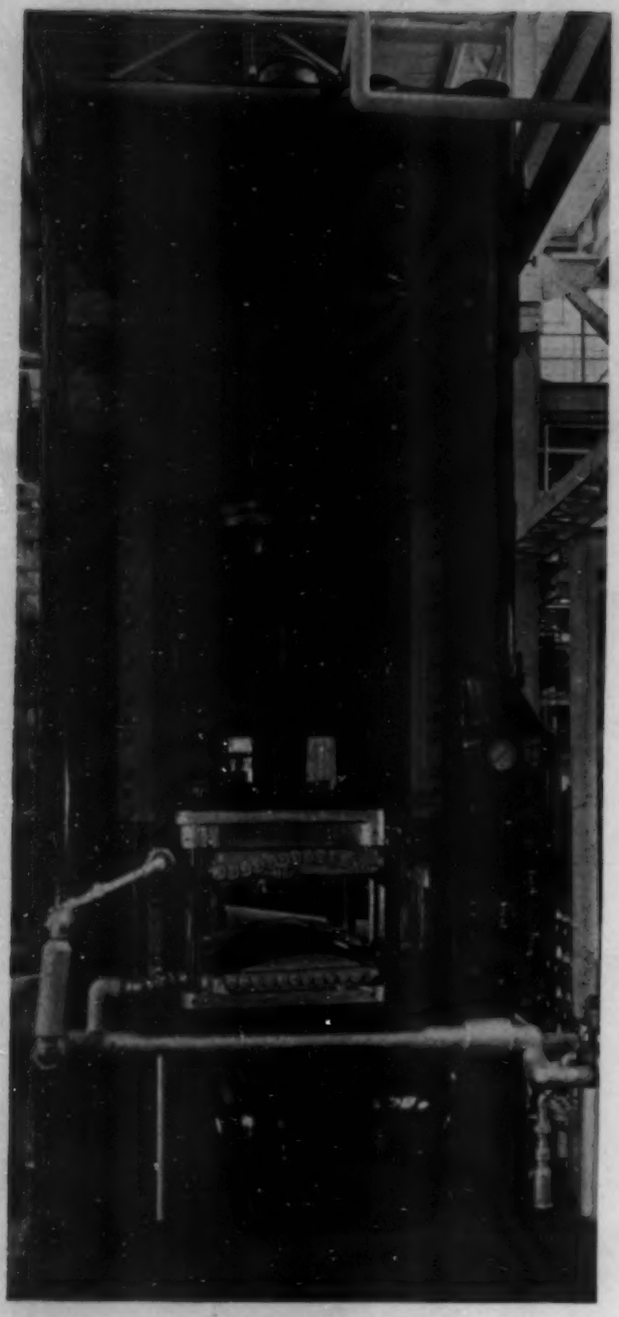
Call freely on UNIVERSAL in solving your plastic problems.



Executive desk Lamp, *featuring the latest improvement in lighting . . . the "cold light" fluorescent bulb molded for Good Lite, New York, by UNIVERSAL.*

Smart lipstick *molded by UNIVERSAL for Don Juan. Plaskon case, with white acetate cameo and base.*

UNIVERSAL
PLASTICS CORPORATION
Factory: New Brunswick, N. J.
New York Sales Office: 500 Fifth Ave.



all the abuse to which a refrigerator door latch is necessarily subjected and also deaden the sound of the metallic click when the door is closed.

The Union Special Machine Co. desired to make a cover for one of their commercial sewing machines. Here, strength and impact resistance were foremost among the properties required. This part is made by using three strips of resin board and two washer punchings in conjunction with black molding material. The Bull Dog Electric Co. has found that resin board has solved a difficult problem in the production of a very strong assembly in their arc suppressor. This job also has to resist surface arcing. Therefore, a combination molding is employed, using resin board lined with a thin strip of fiber. The parts are produced in a gang mold, six at a time and later separated into single units. Two units are then riveted together, using a mechanical riveting machine to form a housing, which insulates and protects the rest of the apparatus from the arcs produced in the making and breaking of contacts.

The statement was made previously that the resin board may be used alone, in the future, for large moldings such as automobile and refrigerator doors. It is along this line that the greatest progress is anticipated during the next few years, since the material has not only shock resistance, but also heat and electrical insulating properties which make its use desirable on a wide variety of applications. For instance, one of the important advantages of the resin board over thin metal is its ability to withstand shock without being permanently deformed. Pieces molded of resin board can, of course, be broken if abused, but any shock received that is below the impact necessary to actually break the part, will not seriously affect its shape. A similar blow on sheet metal would cause a dent that would require repairs and repainting. This quality alone should, in time, enable this material to be used for the often-bumped fenders and hoods of automobiles.

New uses are continually being discovered for this molding board. While the above examples, by no means, cover the complete list of applications where it has been used to advantage, it is hoped they will serve as concrete examples to illustrate the present uses and future possibilities of this comparatively new and interesting product.

The Ford Motor Co. has done considerable experimenting with Bakelite-Rogers boards for automobile body parts. One of its presses, together with a trunk compartment cover for the Mercury car, is shown above. The tray at the left is molded Carterite which is available in the form of blanks already shaped to the approximate form of the finished product. The impregnated fibers are sucked up into molds which bend them to the desired shape before pressing

Handsome

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If your product—or any part of it can be made of plastics—a NORTON molding—in the most suitable material and finish—can add to its sales power.

Write us today for assistance and ideas.

NORTON LABORATORIES, INC.
LOCKPORT NEW YORK

Metal inserts (in trays) used in molding plastic products in the Plastics Dept. of General Electric Company

ASSEMBLY DEVICES

THE HUB OF MASS PRODUCTION WHICH HAS been so ably developed in this country is assembly. Toward the assembly line, or bench, these must be a constant flow of component parts to be put together into completed units. From the assembly line, these completed units flow steadily into the hands of finishers, inspectors, packers, to go into service in a competitive and unsympathetic world.

Their ultimate service so often depends upon how well, how permanently, they are put together, that the matter of assembly has attracted some of the best engineering ingenuity in recent years with the result that a great many assembly devices and systems have been created and made available for specialized manufacture.

Serious attention has been given to economy in assembling manufactured parts. Inserts and fastening devices are designed to require the minimum of time and effort to put them in place. But, once they are in place, they have been engineered to perform their fastening service with no sacrifice in efficiency.

Few of these devices have been designed exclusively for plastics but ever since plastic products have been molded in more than one piece, manufacturers have required a successful method of fastening them together. Since most of them are molded in more than one piece, any manufacturer using plastic parts, either as complete units or as accessories, will find it to his advantage to examine the merits of the various assembly devices and choose the ones best suited to the particular job he has in mind.

The physical properties of the particular type of plastic material used should be considered, and stresses and strains likely to be set up in using the part should be carefully estimated in order to avoid failure of the part in use. Most plastics are capable of supporting inserts which may be molded in or driven in place after the piece is taken from the mold.

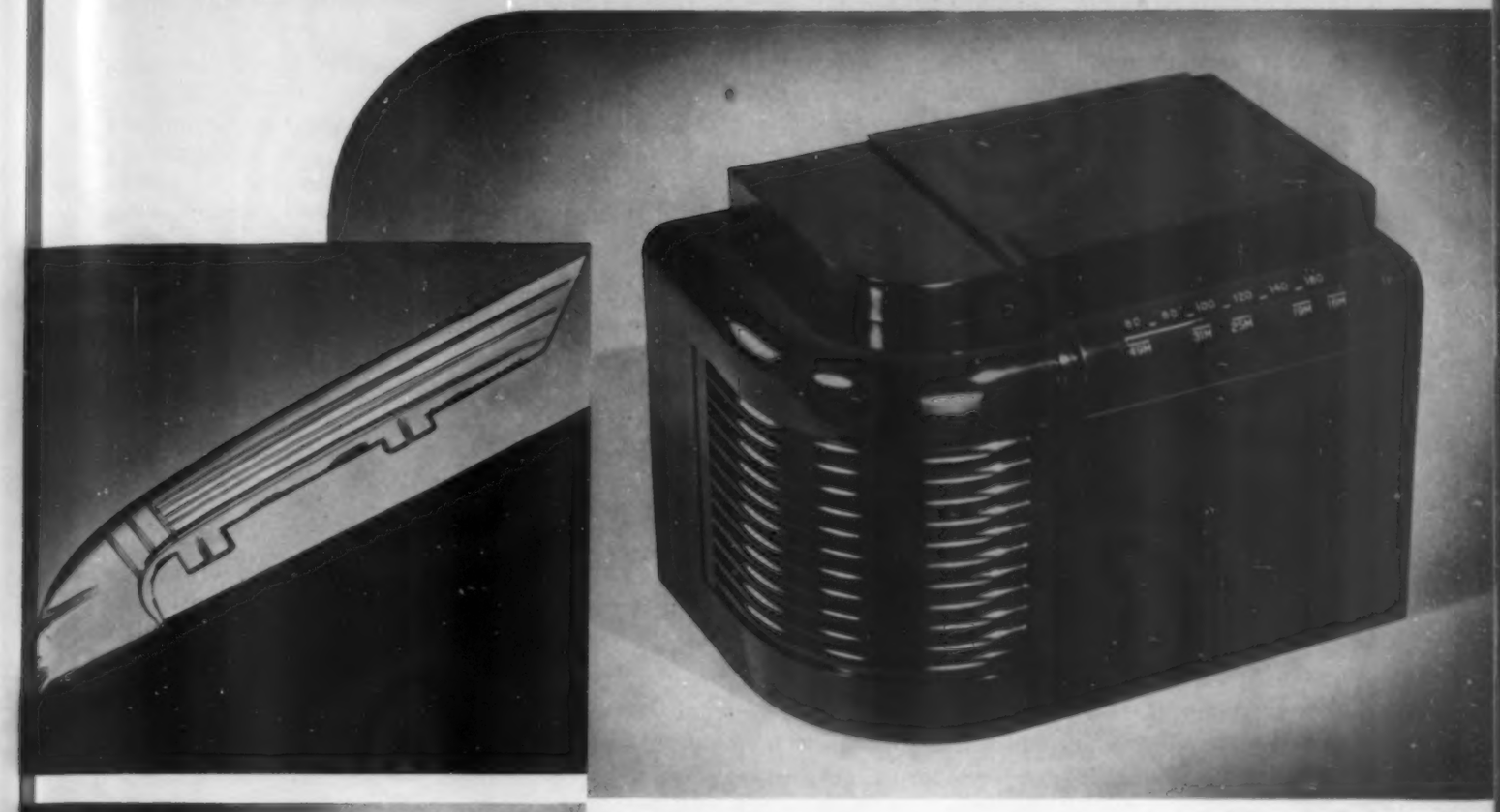
Inserts

There are a number of reasons why inserts are used and almost any mold requires its own particular design. Sometimes they are used with bosses. At other times, they are allowed to project so that plates may be located properly for rapid assembly. There are times when the molded part is of such design that it is difficult to mold inserts in, so a hole which is somewhat smaller than the insert is molded in the piece. Then, while it is still hot, the insert is pressed in and the compound shrinks around it. Molding inserts in place is cheaper, of course, when it is practical to do so.

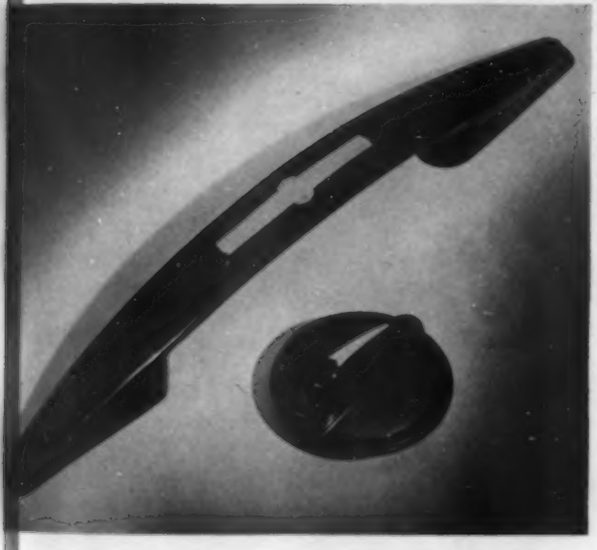
When they are to be molded in, inserts are placed on pins built into the mold and the compound flows around them when the press is closed. Inserts are most commonly used in compression and transfer molding. Since the flow action of the plasticized material is more gentle in transfer molding, this method should be employed where delicate or complicated inserts are required because they are less likely to be displaced or damaged. Glass disks, or dials, are frequently molded in bezels by this method.

(Please turn to next page)

FOR QUALITY MOLDINGS WISE BUYERS CONSULT AICO



RCA Cabinet molded in brown phenolic. The four plastic parts are assembled in the AICO plant.



Radiator ornament in "Lucite" will embellish a popular 1940 car. Molded by AICO.

Metal-inlayed handles for "Estate" gas ranges. Molded by AICO and inlayed by the Chilton Process.

There are excellent reasons why buyers in hundreds of industries come to AMERICAN INSULATOR for all their plastic needs in all materials.

1. Only a company with our volume of business and large molding capacity can afford the full time services of foremost mold design and plastics engineering experts. These specialists will advise you freely without charge or obligation.

2. Their counsel is backed up by a complete toolroom and highly skilled moldmakers.

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There is a limit to the size of inserts which can be safely placed in molding compound. Sufficient wall thickness must be maintained around the insert to prevent cracking when the material shrinks in cooling. In other words, there must be sufficient thickness to the molded part to absorb the shrinkage without letting go. Large inserts should be heated before they are placed in the mold.

Plate inserts made from sheet stock are frequently used in electrical parts. They have shafts which anchor them into the compound. They give a metal base or plate to work on instead of plastic.

Speed nuts and clips

Common screws have been largely displaced by improved variations which speed up assembly and perform economical service for individual applications. Some are made with special studs which project so that a speed nut can be slipped in place to anchor the part. A good example of speed nut assembly is illustrated by the RCA record holder molded by General Electric. The molded part is shipped to RCA in its merchandising container, unsealed (Fig. 4). When it reaches the RCA plant, two metal strips with rubber cushions are slipped in place without removing the molded part from its shipping case. These are held fast by speed nuts which simply slip over projecting studs on the molded part.

Speed nuts are used a great deal on radio and automotive assembly, especially in hard-to-reach places. Originally developed to fasten handles on stoves, there are a number of types now in use, each developed for a particular job. Some of them may be removed as quickly as they are put in place where adjustments or repairs are likely to occur. Others are designed for permanent fastenings and are difficult to remove.

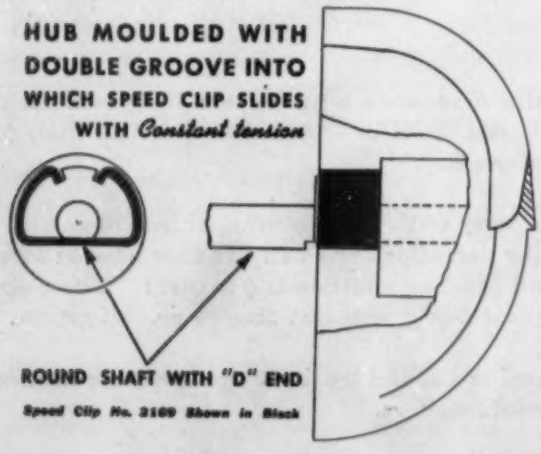
Speed clips and speed rings are provided for attaching round knobs and similar parts (Figs. 2–3) and are so shaped that the harder you turn the knob, the tighter they grip. Yet, they may be quickly removed and used again should the part require adjustment or renewal. While speed nuts and speed clips provide a means of rapid assembly, they should be concealed inside the piece because they do not present a finished appearance.

Self-tapping and drive screws

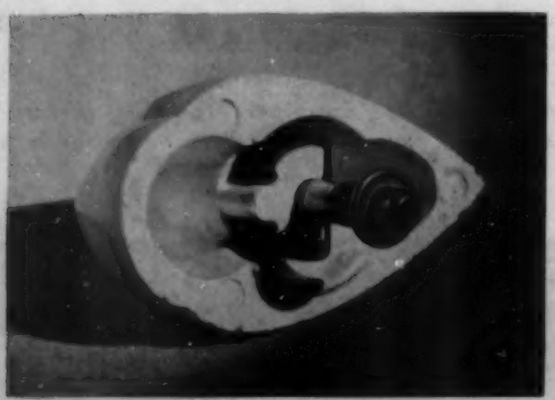
Hardened metallic drive screws are used for making permanent fastenings only. They are driven in with a

Molded urea indicator knob (3) showing Tinnerman Speed Clip attached. Diagram (2) illustrates the working of this assembly device. The RCA record holder (4) is shown in its shipping container, where (without removal from the container) Tinnerman Speed Nuts are used to fasten two metal strips with rubber cushions on which records rest

2


HUB MOULDED WITH
DOUBLE GROOVE INTO
WHICH SPEED CLIP SLIDES
WITH Constant tension
ROUND SHAFT WITH "D" END
Speed Clip No. 2169 Shown in Black

3



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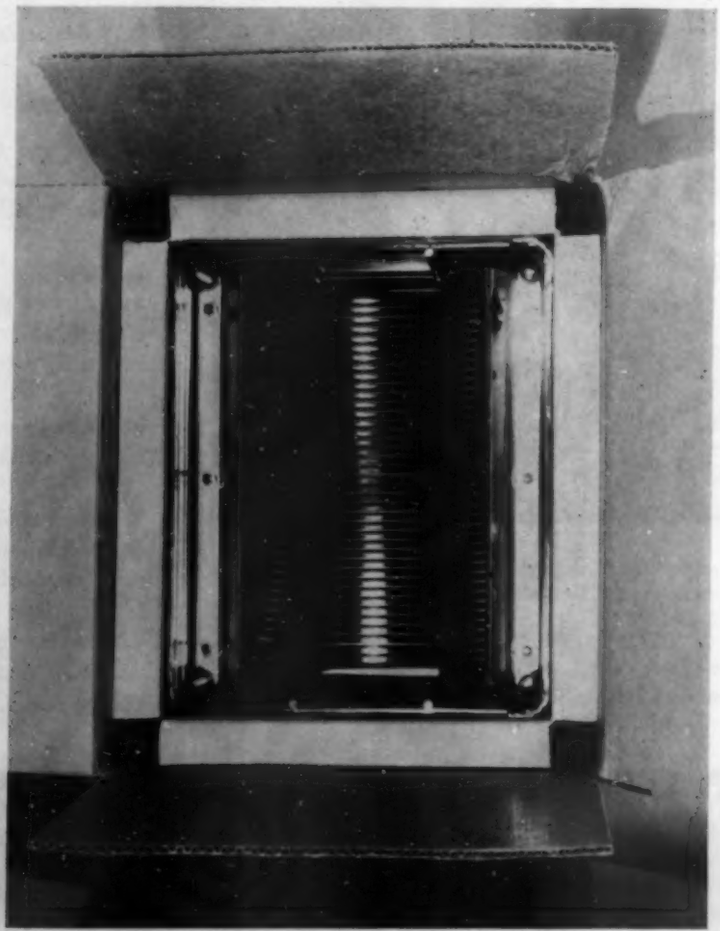

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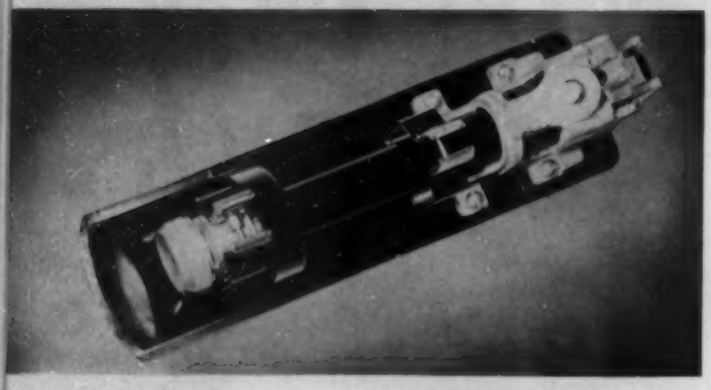
6



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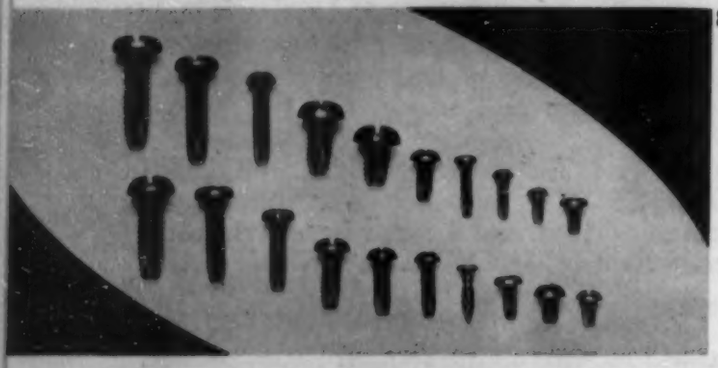

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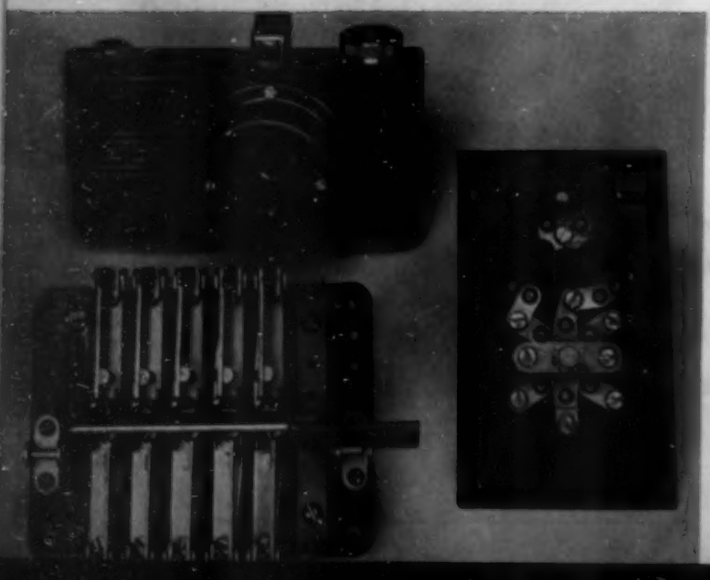

9

hammer or may be pressed into holes drilled or molded in the material. As they cannot readily be removed, they are recommended only for the assembly of parts that do not have to be disassembled for servicing or repair. (See Figs. 8-9.)

Hardened self-tapping screws are available in two types for use in plastics, one of which forms its own threads by extruding the material and the other of which has longitudinal flutes parallel to the axis for cutting away the material. The former is recommended by the manufacturer for use in all types of plastics where the area immediately surrounding the hole has a sufficient mass to absorb the compression incident to the formation of the threads. In friable plastics or those having a granular structure, the fluted type of screw is used since very little, if any, strain is transmitted to the material adjacent to the hole. Thus, in the case where fastenings are made to bosses or close to the edges of thin sections, the fluted fastener finds its greatest field of application.

Cross slot screws

Another patented screw, with either machine screw threads or self-tapping threads, is distinguished by a recessed head and an X-slot so designed that it clings (Figs. 5-6) to the special screwdriver provided, and is easily started in hard-to-reach places. The double slot makes it possible to set up the screw much tighter with a minimum of effort. Either hand or power equipment can be used.

An additional advantage is reported by users of this double slot screw in that its shape allows a mere quarter turn to align properly with other screws for the sake of appearance. There are many reports of substantial savings in assembly through the use of these recessed head screws because the screwdriver "nests" securely in the double slots without any special effort of the operator to keep it in position.

Aero-thread screws

Quite recently, the aero-thread screw (Fig. 11) came to our attention. This features the use of a spirally wound insert or bushing of precision-formed bronze spring wire in which hardness, strength, surface smoothness and anti-frictional qualities are carefully controlled. The insert is screwed into a tapped hole and forms the seat for the screw, protecting the threads from wear and

Phillips patented cross-slot screws (5) cling to the driver, leaving both hands free for the fastening operation. Their neat appearance is illustrated in the Nu-Era WHISKer (6). Cutting screws made by Shakeproof Lock Washer Co. are used on the part shown (7). The new Type Fhardened self-tapping screw (8) is made by Parker-Kalon Corp., as are the various types of self-tapping and drive screws used in the assembly of parts pictured (9)

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We offer, under one roof and one control, a complete and versatile plastics molding service that embraces every phase of tool and mold making, model work, design and engineering aid, metal work and assembling.

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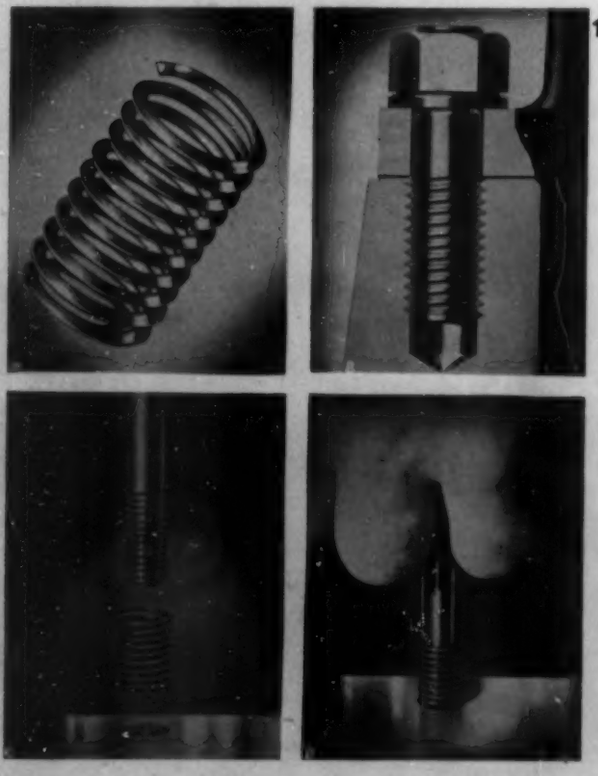
10

Bead Chain Mfg. Co. provides the permanent fastening for the cap on your Sparklets (10) and for many other assembly jobs, especially electrical. 11—Air Associates, Inc.'s new Aero-Thread. The Homer Spline Lock (12) is pictured holding two blocks of styrene together but allowing them to slide horizontally



11

resulting in a strong thread with a hard, smooth surface against which the screw fits.

As indicated by its name, this device first found application in the aircraft industry where high-strength studs and cap screws are required but because of its high strength and great shock resistance, the screw is attractive for use in plastics assembly where compactness and lightweight are desirable.

Shakeproof screws

Another successful fastening device quite commonly used is called a shakeproof screw. There is a groove cut into the screw itself which converts the screw into a tap. As it enters the material, the screw cuts its own clean sharp thread as it turns. Another device, by the same manufacturer, provides a washer as an integral part of the screw so that none can be driven without a lock washer under the head to protect it from vibration—and no time is consumed by picking up separate washers and putting them in place. (See Fig. 7.)

Metal chain

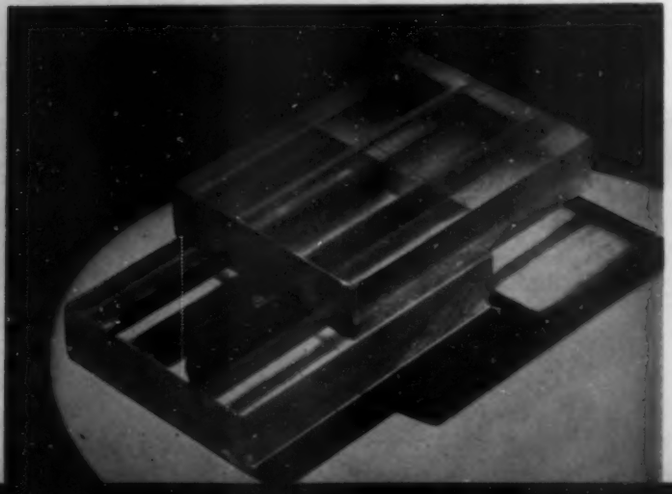
Practically all of present-day electric light sockets are equipped with metal chain pulls that are usually inserted into a molded or drilled hole in the finished plastic piece. This same type of chain may also be cemented or riveted into other plastic parts where it serves a definite purpose. A good example is its use on the molded head of the Sparklets soda syphon. Here, the chain is attached to the removable cap to keep it from becoming mislaid or lost when the syphon is being used. Since the chain is light in weight and flexible as well as neat in appearance, it makes a decorative and useful assembly means. (Fig. 10.)

Spline lock

The most recent fastening device to make its appearance is the spline lock (Fig. 12) which consists of two keys or splines which fit into slots cut into the parts to be fastened together. These slots are cut at opposing angles and, when joined together by splines, form a tight and lasting fit. If the splines are not cemented in place, the parts may be quickly taken apart if desired.

There are many obvious applications for the spline lock in furniture, radios, aircraft and automotive manufacture but its introduction is too recent to predict its status in the plastics field. Perhaps this will provide the solution for architectural problems of sheet installation.

12



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These twelve months just ending are no exception.

There have been pioneering achievements that have proved yet again the value of Auburn's long years of experience. There have been "run-of-mill" jobs, bettered because of Auburn's painstaking care in mold-making, molding, and long series of exacting inspections.

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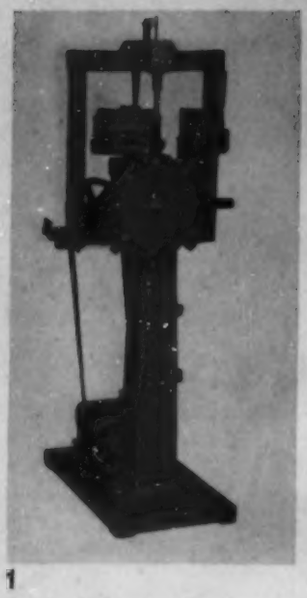

1 2

Operated by a hand arrangement, a foot device, or driven by power, Markem machines (1) imprint plastic surfaces with special quick-drying inks. One of these machines is used to print numbers identifying each of the 40 separations on the RCA record rack (2) molded by G-E's Plastics Department

APPLIED DECORATION

IT BEGINS TO LOOK AS THOUGH PLASTICS CAN take almost any sort of decoration a manufacturer wants them to wear. Time was when the choice of decorative means was limited to chipping the letters or pattern in the cold, hard steel of the mold itself so it would reproduce in the part as it came from the press. That proved slow and costly and as a result, machines were developed to cut or stamp letters and designs in the plastic pieces after they came from the mold. Then came demands for more extensive use of color. These were met by various techniques of printing and decalcomania. Metal inlays became popular. Metal leaf stamping is indispensable. Even halftone offset lithography is possible now on transparent sheet.

No one can say that one method of decoration excels another. Each is designed to meet certain requirements set up by individual conditions surrounding the parts being turned out. The point is that almost any decorative effect desired can be successfully applied in one way or another. That methods and systems have been perfected during the past year which permit rapid and economical decoration for almost any plastic surface.

Printing

Printing is extensively used for product identification on molded containers and displays. This type of decoration is also used on fountain pens, radio dials, instrument panels, slide rules and advertising novelties.

Special inks which adhere to the non-porous surface of plastic materials have been improved during the past year so that better permanence is obtained. Special machines have been designed to imprint non-absorbent surfaces by using inexpensive, long-life rubber plates and quick-setting, air-drying chemical compounds prepared especially for this work. A wide variety of time-tested colors are available and the imprinted objects are ready for packing in two or three minutes after the imprint is made. They can be dried on a conveyor belt while being transported from the marker to the shipping department. Round or flat surfaces may be printed with the rubber plates which work equally well on plastics, metal or glass.

Another exclusive process prints embossed lettering and designs on any group of plastic materials. The printing can be accomplished on flat, spherical, convex, concave, tapered or irregular surfaces with good adherence and with a glossy surface in harmony with the molded part. Any color or shade can be obtained.

By still another method it is possible to print four colors in one operation. Halftones and line cuts may be reproduced accurately. Plastic parts are fed into a hopper from which they travel automatically through the printing and drying operations to come out ready for service in a few minutes. The drying heat is so controlled that no shrinkage or distortion results. Thermosetting materials only are printed in this manner.

Thermoplastics are by no means neglected and equally effective methods of printing their softer surfaces are available. Pens, pencils, pocket knives, containers and other products may be printed successfully in all-over designs regardless of shape. Pens and pencils with tapered ends may be printed with no overlap of pattern and no visible joining line. (*Please turn to next page*)

5 Plastic Parts

All Skillfully Molded By Kurz-Kasch

It was no easy job to produce the five plastic parts on this Exact Weight scale . . . yet once again, Kurz-Kasch arose to the occasion. Working with Bakelite, Crystalite, and Beetle, this largest and one of the oldest exclusive plastic molders created five plastic parts . . . all perfectly molded . . . all adding new beauty and permanence to this high-accuracy scale.

If you require plastic parts difficult to mold . . . plastic parts of unusual contours . . . or parts in unusual quantities, turn to Kurz-Kasch. There you will find the skilled die builders, production operators, and modern equipment so vital to the success of a modern plastic job.

Furthermore, if stock dies will serve your needs, Kurz-Kasch has a large selection . . . any of which can be used without extra charge.

When you need plastic parts, think of Kurz-Kasch. Write for quotations and full particulars. KURZ-KASCH, INC., Dayton, Ohio.

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There is no substitute for experience, on which count Kurz-Kasch scores heavily—being one of the very oldest molders of plastics in the country. Nothing too large or difficult. No run too long. There is no substitute for seasoned mold builders, of which Kurz-Kasch has many, some of them as old in service as the art of commercial molding itself.

Nor is there any substitute for production equipment, the latest in tools with which to fashion the product. Here again Kurz-Kasch, with their large modern plant, stand out most prominently. The various plastic parts used in the manufacture of the very attractive "Westclox" at the left are typical of the innumerable other parts fabricated for other companies. On your product, if plastics are in order, Kurz-Kasch can serve with equal skill and satisfaction.

As workers in all the commercial materials of the day, Kurz-Kasch solicits your inquiry.

KURZ-KASCH, Inc. Dayton, Ohio

KURZ-KASCH Inc.

3

By a special method, a machine perfected during the past year by Color-Kraft, Inc., prints embossed letters and designs, in any color, on flat, spherical, concave, convex or other irregularly shaped plastic articles. Printed by this concern are the pieces shown in Fig. 3—Beech-Nut Beechies display rack molded by Shaw Insulator Co.; ash tray, by Kurz-Kasch, Inc.; and two jars, by Colt's Patent Fire Arms Mfg. Company

4

Pens, pencils, nail files, pocket knives and similar small pieces (4) whether their surfaces are flat, round or tapered, may be printed with letters or other decoration by a patented process developed by Quick Point Pencil Company

Such printing is usually done in the printing plant rather than in the molder's shop but printing equipment is available to the molder or manufacturer who wishes to print his own product. Either hand-operated units for simple production jobs or automatic equipment designed for elaborate production schedules, where large quantities are handled, may be obtained.

An idea that promises rapid acceptance in the field of transparent containers is based upon the recent discovery of an ink that permits printing by photo offset on transparent sheets. The finest halftones may be reproduced in this way and may be turned out in speedy production to satisfy almost any demand.

Stamping

Roll leaf stamping is standard practice for branding plastic products with trade names, graduated scales, directions for use and decorative designs. Metal foil and pigmented tape in a wide range of colors is provided for molders and manufacturers to do their own stamping but there are service companies where the work may be done outside the molder's shop if desired.

Heat and pressure are required to force the metallic or pigmented leaf into the plastic surface and it becomes so fused into the material that it cannot be scratched nor rubbed off. The process finds wide application in the packaging field as well as in display.

Many types of machines are available for the process of roll leaf stamping. They operate by hand, by foot or by power and may be manually or automatically controlled according to production demands. Roll leaf, which is composed of either metallic or pigmented colors mounted on paper to provide a means of carrying continuous color through the machine, is placed on a bar in front of the head of the press. The leaf is threaded into a roll feed which carries it beneath the metal stamping die. As each impression is completed, the roll feed pulls new leaf under the die for the next impression.

Presses are equipped with mechanical handling and compensating devices which take care of any ununiformity in thickness and shape of the pieces being stamped. Stamping presses have been highly developed for rapid production of special applications, often in conjunction with drilling and other finishing operations which complete and stamp the part without any manual attention being required.

With the perfection of the process and the availability of white and other pigmented colors, roll leaf stamping

Many large parts have already been fabricated economically on our giant presses . . . Automotive Steering Wheels, Garnish Moldings, Instrument Panels, Fog Lamp Shells, Radiator Grilles, Building Tile, Map Case Covers, Refrigerator Parts, Clock Cases & Containers.

Other applications in the larger field include Radio Cabinets, Phonograph Cabinets, Business Machine Housings, Airplane Accessories, Typewriter Cases and Covers, Refrigerator Parts, Seat Arms, Furniture Trim and Decorative Parts, Shampoo Bowls, Gun Stocks, Decorative Bases, Trays & Containers.

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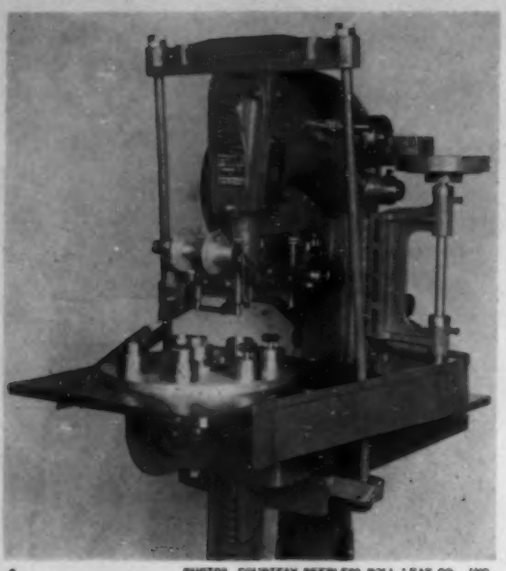
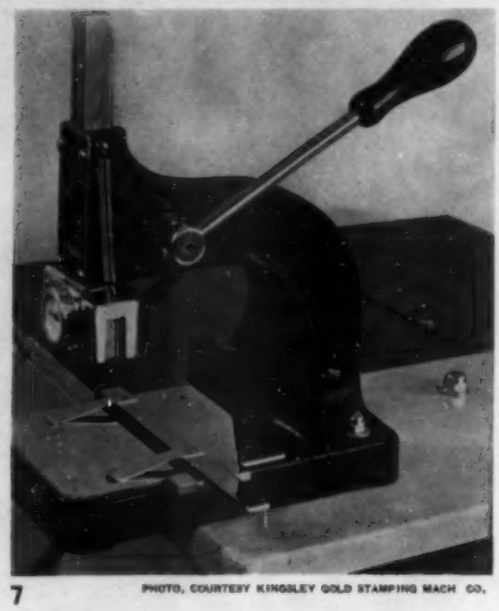
5



6 PHOTOS, COURTESY PEERLESS ROLL LEAF CO., INC.



7 PHOTO, COURTESY KINGSLEY GOLD STAMPING MACH CO.

Trade names or decorative motifs can be reproduced in gold, silver and colors on plastic items (5) by roll leaf stamping on suitable machines. The Peerless Roll Leaf Co.'s press, pictured in Fig. 6, is designed especially for stamping plastic sockets. For small jobs, a Kingsley precision-built gold stamping machine (7) dependably and economically prints individual names, etc., on plastic parts

has displaced much wiping in by hand which used to be done to obtain contrasting letters and numerals.

Engraving

Engraving may be done by hand or by portable engraving machines. These machines use no heat. Instead, a small rotary tool guided by hand cuts lettering or designs into the plastic part. Although guided by hand, it operates on the pantograph principle whereby the operator traces the outline of larger letters while the tool cuts them into the plastic in reduced size.

Decalcomanias

As old as the hills, this method of decoration is just being introduced successfully for the decoration of plastic surfaces. The delay was occasioned because the usual adhesives that hold decalcomanias in place were ineffective on plastics. They wouldn't stick. Special solutions in which the plastic surface is first treated, now provide a satisfactory adhesion and some unusual effects are obtained. A good example is offered in the Stewart-Warner upright radio, designed by Barnes & Reinecke. Molded of phenolic, this cabinet costs approximately one-half as much as though genuine fine burl and costly sliced walnut were used. It cannot delaminate in humid climates. The finishing and decorating is done in the plant of Stewart-Warner.

It is generally conceded that plastic surfaces are beautiful in their own right and over-all decorating of this sort has been discouraged. Plastics are structural materials, however, and there is no good reason why they shouldn't be treated as such. Automobile instrument panels, although made of steel, have long since been made to look like fine grain woods and the public likes them that way.

This introduction of decalcomania decoration on the Stewart-Warner radio implies a trend worthy of careful watching. We have illustrated also a group showing varied examples of decalcomania decoration on plastic surfaces in the package and novelty field which carry their own suggestions of practical applications of this easily applied ornamentation.

Metal inlays

There is an increasing tendency to combine plastics with metal, both for structural and decorative reasons. The contrasting gleam of metal against the lustrous

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surface of plastic enhances the appearance of both materials. Interesting patterns of light are picked up and reflected by bits of metal embedded in the more somber plastic background.

There are any number of places where metal inlays are practical and attractive. You will find them in your 1940 automobiles, in radio knobs and grilles, in fountain pens, in plastic displays, cosmetic containers, handles on commonplace household equipment, and in advertising and directional signs.

There is no limit to the design possibilities of decorating with metal because any pattern or design that can be cut from thin stock can be inlaid in plastics by one method or another.

Last year, we pointed out that inlays may be molded into plastic pieces or put in after the piece is molded. The latter method has proved more popular during the past year and one company, whose method was described, has perfected automatic machinery to handle metal inlays with such facility and speed that quantity production is now available without limit. These inlays are forced into plastic surfaces cold, yet they are so shaped that they become anchored permanently.

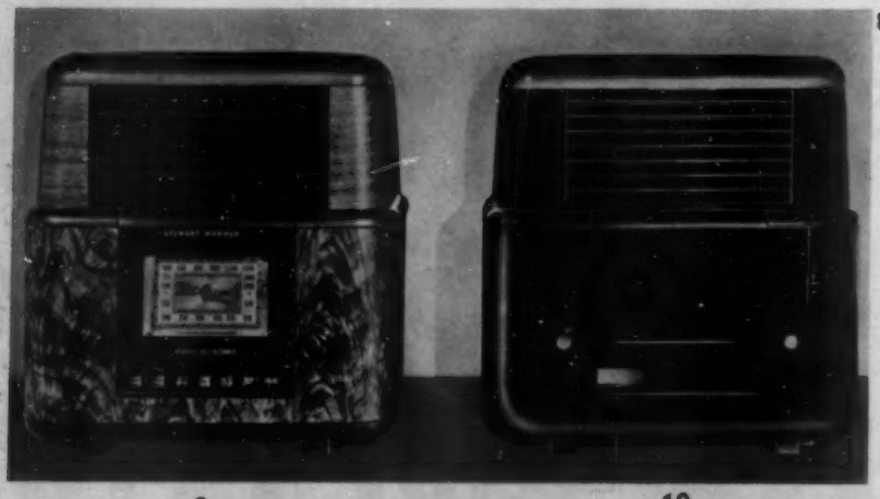
Other inserts and trade name plates may be attached to the plastic surface as the final finishing operation and patented drive screws or speed nuts are used to hold them securely in place.

Metal plating

Plastics, by simple treatment with certain solutions, may be plated with almost any desired metal. The solutions are necessary to prepare the non-porous surface of the plastic material so that the metal plating will stick. Although not much progress has been reported during the past year, the process indicates its value in lining cosmetic jars with silver to prevent absorption, as well as for exterior decoration of the molded parts.

The process involves electroplating as well as chemical processing and there are not many plastic plants equipped for this type of work. Electroplating service is available, however, to molders or manufacturers who are in need of such service.

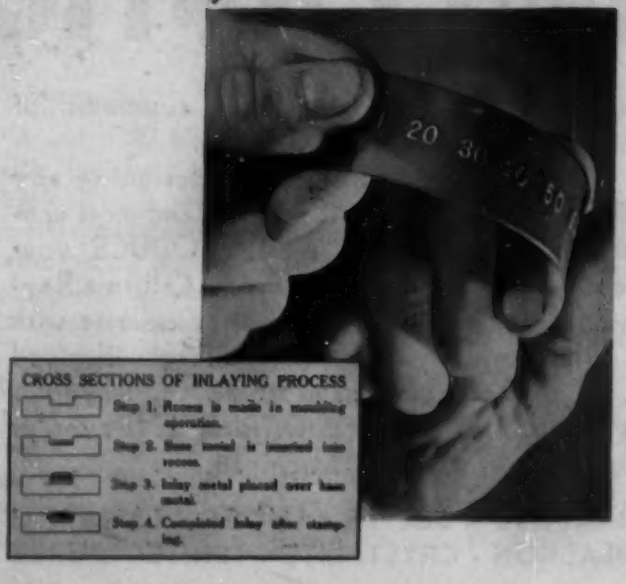
In this brief article it is quite impossible to point out and describe in detail the many methods available for applied decoration. We can say in conclusion, however, that it is perfectly possible to decorate plastic products in one way or another to meet any demands or market conditions that are likely to arise.



8

Stewart-Warner's upright radio is shown as it appears in black Durite and also with burl walnut decalcomania (8). Other decalcomania decorations are shown in Fig. 10, and Fig. 9 illustrates how metal inlays are applied cold by the Chilton Process

9



10

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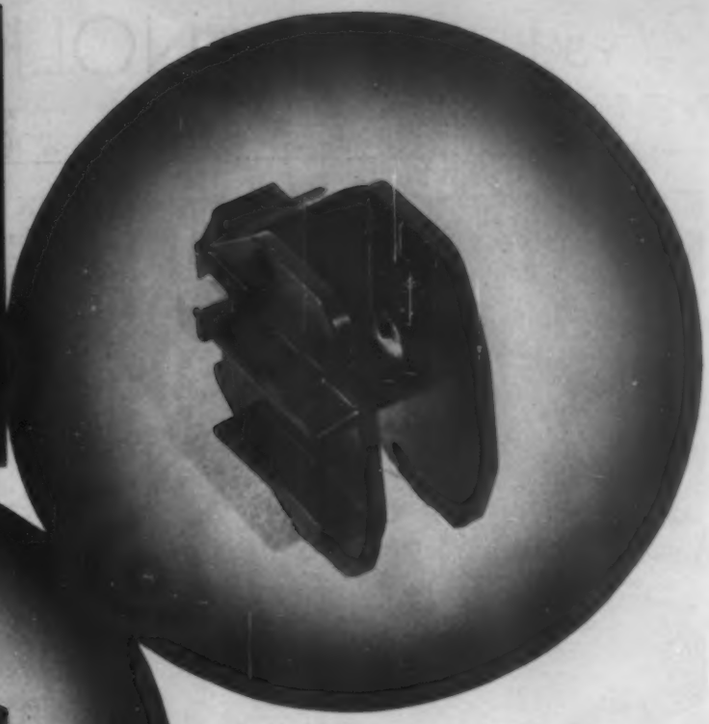

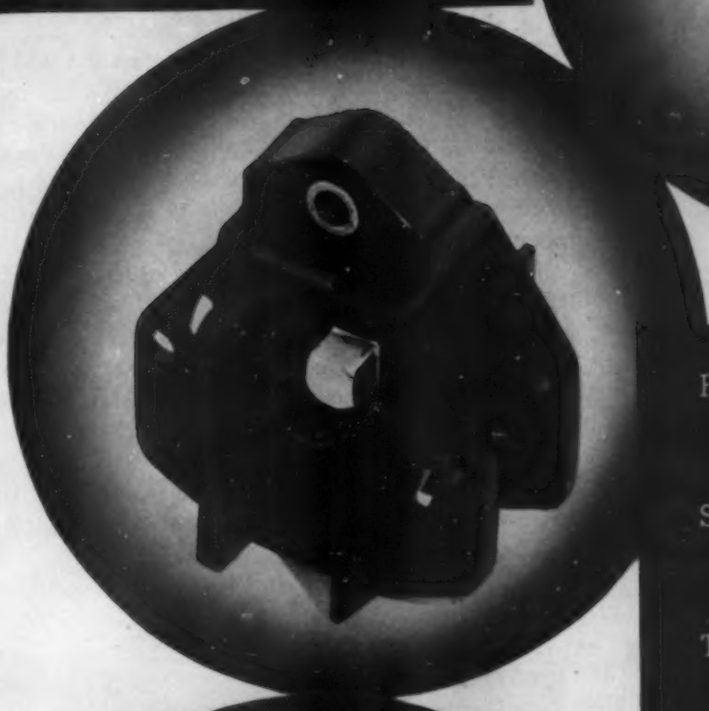

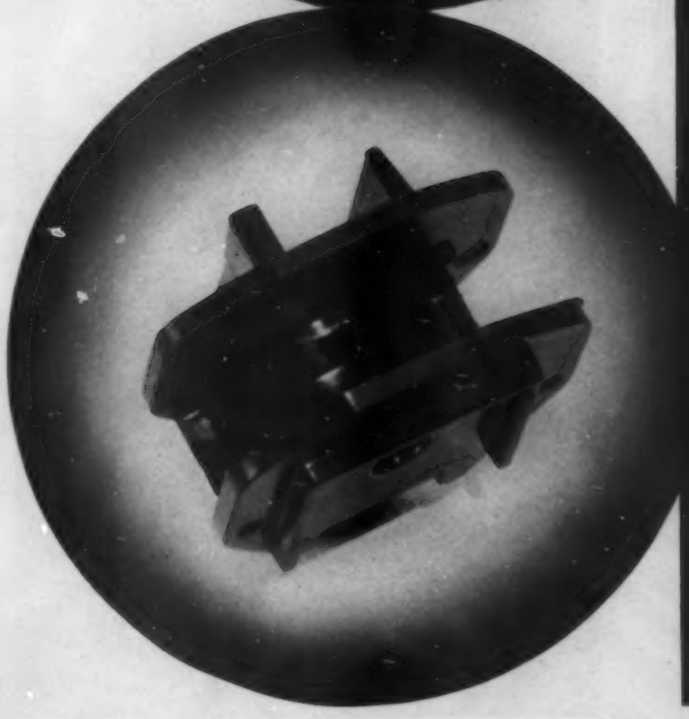

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CASTING PHENOLIC RESINS

by OTTO HANSEN*

1

IN COMMERCIAL MASS PRODUCTION OF CAST phenolic resin, lead molds are used. These molds are made in the phenolic resin plant and according to daily requirements. A 750-pound batch of resin may be cast into several different forms.

In order to reproduce a certain shape in cast resin, a steel form or dipping arbor is first made in the identical proportions of the casting desired, actually a duplicate in steel. For practical purposes the length is limited to 24 in. although longer shapes can be made.

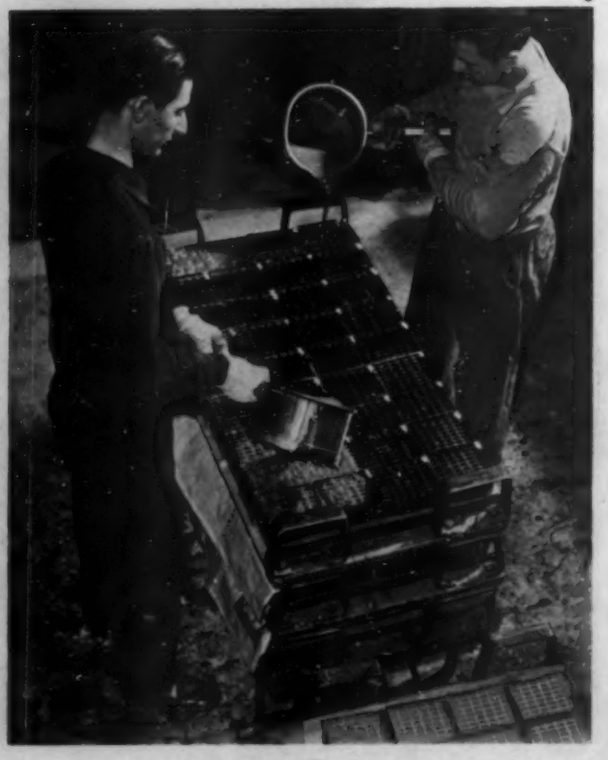
The steel form is mounted on a plate upon which is fastened a handle. The operator dips the arbor into a pot of molten lead and upon withdrawing, the arbor will be encrusted with lead solidified due to the lower temperature of the steel. The lead casing is jarred loose, resulting in a one-piece open mold. The operation is repeated as many times as desired.

In casting phenolic resins, no method has successfully replaced that of filling the molds by hand; the same applies in producing grained or mottled effects. Casting devices of all sorts have been tried and discarded, for by no mechanical means can the beautiful variations created by a skillful *mottler* be duplicated.

The resin, ready for casting, is drawn from the vacuum kettle into one-gallon pots and, if to be grained, brought to the mottling bench. Here the mottler dips a glass rod

*Marblette Corp.

2



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Resins, drawn into one-gallon pots from the huge vacuum kettles in which they are cooked (1) proceed to the mottling bench (2). A glass rod that has been dipped into resin of contrasting color is thrust into the base resin and swished about, up and down and from one side to the other until the desired degree of mottling is attained. The prepared resin is then poured by hand into lead molds (3). The molds shown are for cutlery handles. (Courtesy Marblette Corporation.)

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Maximum dimensional accuracy of entire part and in placement of inserts.

Parts requiring fragile inserts, including ceramics and glass.

Intricate shapes and reduction of weight by adequate coring.

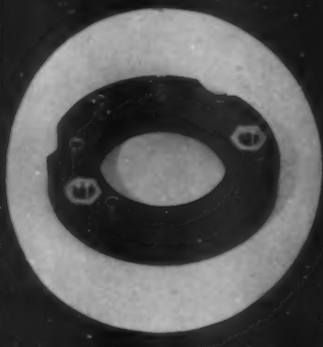
Parts of large area requiring long flow in molds.

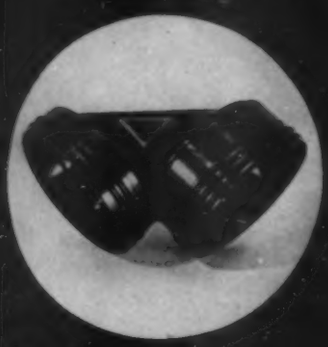
Uniform cure regardless of cross-section, resulting in higher impact strength.

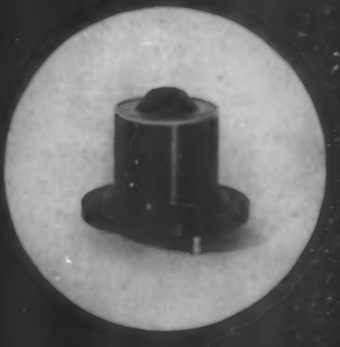
Use of canvas-filled or other high impact molding compounds.

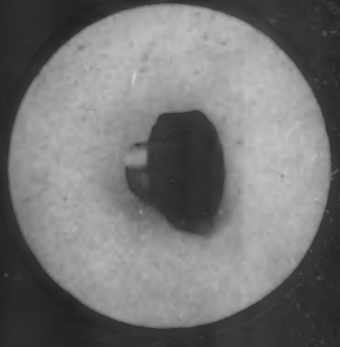
Molding over or coating metal castings.

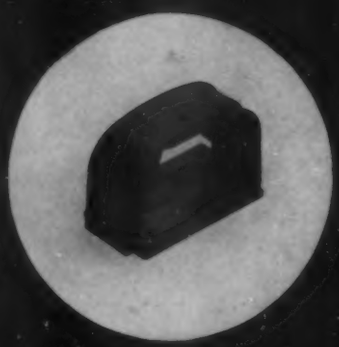
Substantially longer mold life, fewer rejects and lower finishing costs.











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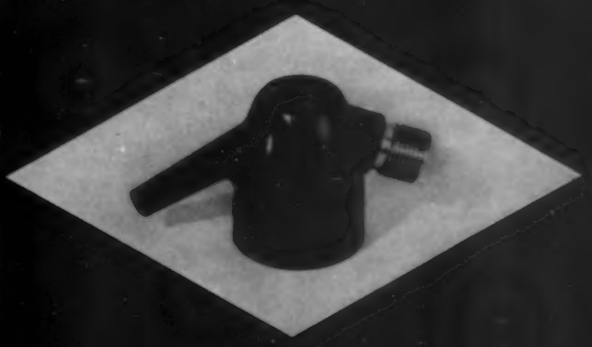

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5

(4) Lead molds for casting rods, cylinders and special shapes are formed by dipping master steel patterns into molten lead. (Photo, courtesy Catalin Corp.) (5) As soon as molds are filled, they are trucked off to baking ovens where they are allowed to remain until they reach the necessary hardness. The casting is loosened for removal (6) by tapping the bottom of the mold with a hammer. (Photos, courtesy Marblette Corp.) These resins can be cast in rubber molds as evidenced by the 12 dramatic Marblette figures in the U. S. Federal Building at the New York World's Fair. Edward Burdick, designer of the government exhibit, is shown below (7) with the first three of the figures. (Photo, courtesy Diorama Corp. of America)

6

7

into a resin of contrasting color and quickly removing it, plunges the resin covered rod into the pot of kettle resin, swirling it about, leaving a trail of oddly shaped veins. The mottled resin is then poured into molds which, when filled, are immediately put into the baking ovens. Having been baked to a required hardness, the phenolic resin casting is removed by striking the bottom of the mold with a mallet or automatic hammer, thus jarring it free. The lead is subsequently remelted for further use.

It will be readily noted that by the dipping arbor method of lead mold making no undercuts can be permitted; also that draft must be all one way. On a 1-in.

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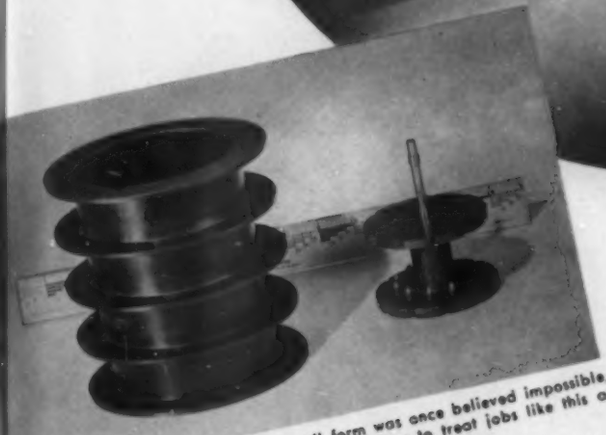

1. (left) Do you need exceptional sizes? Here is one of the largest moldings ever made. An agitator for industrial washing machines. Mold designed and built and product molded by Tech-Art's master craftsmen.

2. (right) Is electrical resistance important to you? This giant circuit breaker box can stand terrific punishment because it's a Tech-Art product.

3. (left) Molding thin fins as on this coil form was once believed impossible, but Tech-Art's master craftsmen have learned how to treat jobs like this as straight production work.

4. (right) Even more intricate than it looks is this insert-studded electrical industrial molding, but Tech-Art molders thrive on intricacies. Your toughest job won't faze them.

5. (left) Is extreme accuracy your requirement? Note this tiny molding, held to hairline tolerances, yet produced as a regular production job at Tech-Art.

6. (right) Inserts are often a weak point . . . but not when Tech-Art designers and mold makers plan in advance for them. For instance, note the intricacy of this radio tube base, tested and passed for exacting government aircraft use.

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rod dipping arbor a taper of .001 in. per running inch of the form is preferred. Tube molds require more taper due to shrinkage of the cast phenolic resin, during the hardening process, about the lead core. Insufficient taper would make it difficult to remove the hardened casting.

Rubber molds

Latex molds[1] are used for reproducing statuary and undercut shapes[2] but this method is generally used by those who wish to do their own molding in cast phenolic resin. Designers and decorators who seek the translucence or brilliant colors of cast resins for non-commercial purposes or for producing a limited number of oddly shaped objects not possible of fabrication from stock shapes, find that rubber molds provide a means to obtain these unique effects.

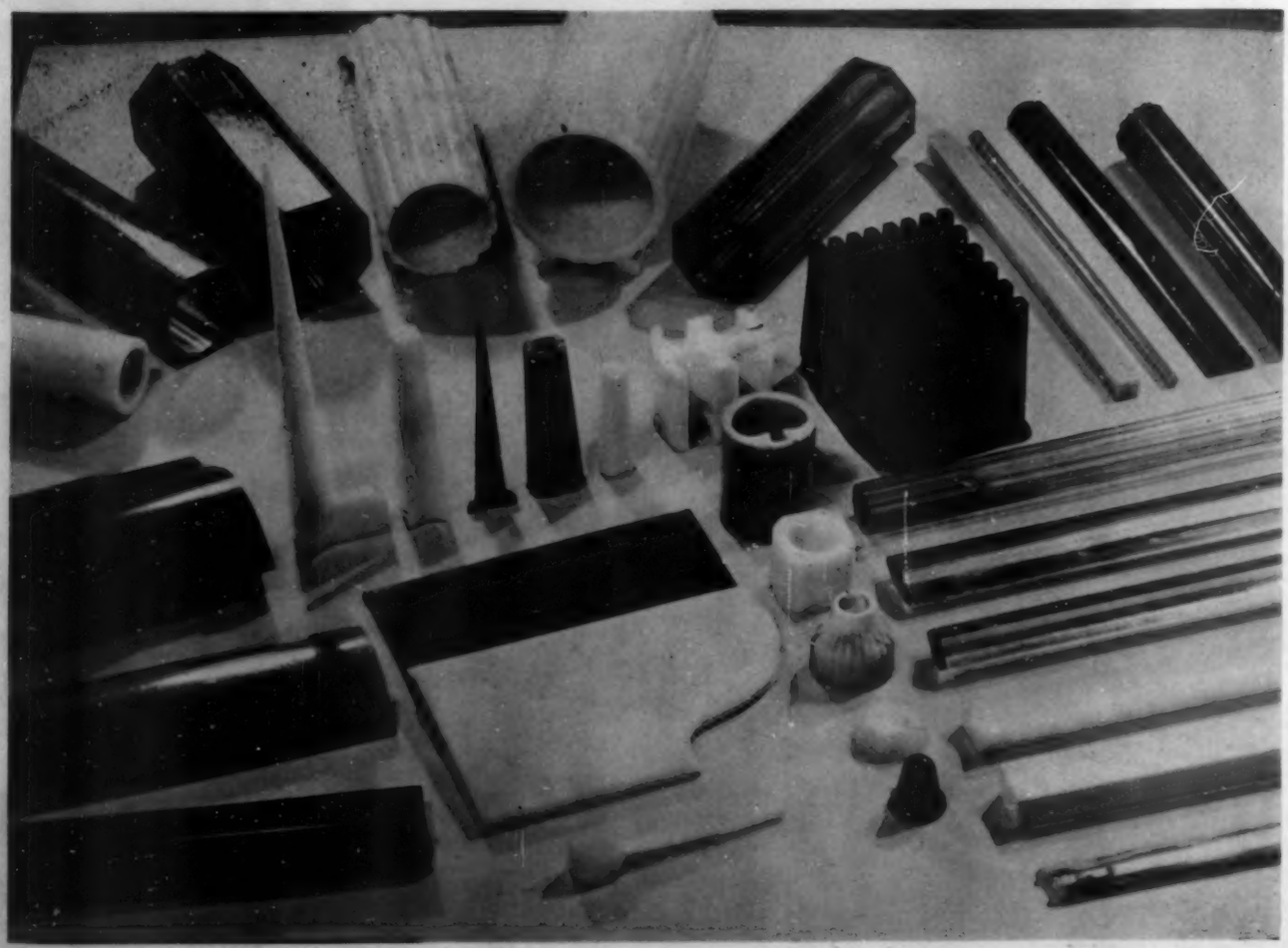
Model makers, too, who are called upon to provide miniatures or full scale models of plastic parts before production molds are made—even models of entire civic communities—are learning that duplicates can be economically turned out in rubber molds from wood or plaster models.

The proper technique of making rubber molds is pretty much in the development stage but in recent months a number of sculptors and designers have turned out remarkable reproductions which lead us to believe that with a little experience and persistence, this method of casting resins will grow in importance and popularity.

It has been common practice, once the molds were made, to send them to the resin manufacturers plant for filling with resin and curing, but this may be unnecessary in the future because casting resins are being made available which will cure at room temperature within 24 to 48 hours. This pleases the artist who wishes to keep his designs to himself until they are completely cast to his satisfaction, and is likely to widen the use of rubber mold casting in both industrial and fine arts.

[1] "Prevulcanized Molds," Modern Plastics, March, 1939.
[2] "A New First," Modern Plastics, February 1939.

Cast phenolic resins are available in an extensive range of standard shapes—round, octagonal and square rods; fluted, ribbed and plain tubes; sheets, blocks, etc.—which are easily and quickly sawed, turned, drilled, threaded, embossed, carved, faceted and polished to the desired finished form. A comprehensive number of widely diversified articles can be fashioned from these ordinary castings. Other stock shapes include handles for cutlery, kitchen equipment and razors; gear shift knobs, automobile fender guides, clock cases, radio housings, parts for lamp bases, etc. Special castings required in quantity are usually prepared to the customer's specifications. The cast pieces shown below were produced by the Marblette Corporation



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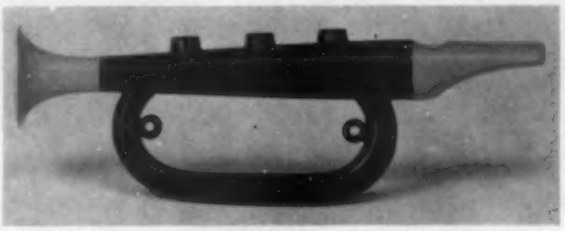

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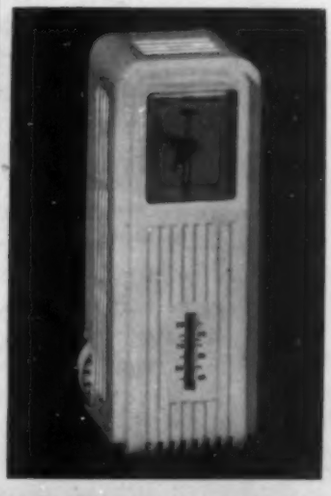

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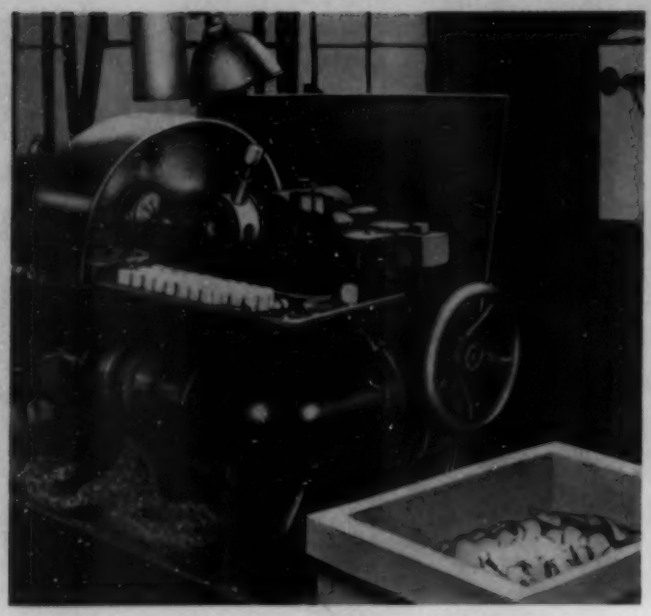
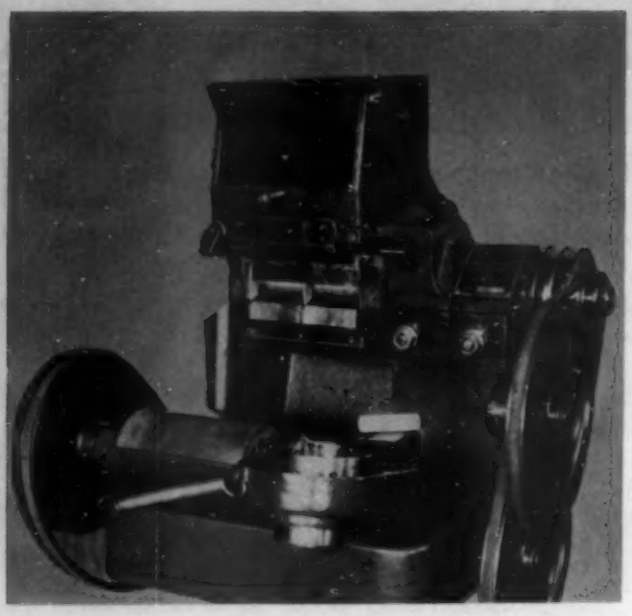


Regular machine shop equipment, such as the lathe above, is used for fabricating cast resins. In quantity production of screw machine parts, operations similar to those applied to metals are used except that tools are ground somewhat differently and ranges of feed and speeds adjusted to the requirements of the material



Automatic abrasive forming machine (above) has superseded many of the time-consuming hand operations formerly employed. Cut rods fed into the hopper drop automatically between the stones and as many as 350 $1^1/_2$-in. balls are turned out per hour. Ten thousand balls, $^3/_{16}$-in. in diameter, can be produced in an hour

MACHINING CAST RESINS

by E. S. HORSMAN*

IN CONSIDERING THE FABRICATION OF CAST phenolic plastics, it is perhaps important at the outset to emphasize the principal differences between cast plastics and molded plastics.

Cast phenolics are supplied to fabricators or to customers in fully cured rods, sheets, cylinders and special castings which are converted, through fabrication, into finished articles. The special castings approximate as closely as possible the configurations of finished parts, and where they are integral units, such as knife handles, shaving brush handles, pen tapers, etc., it is necessary only to remove the flash, drill holes for the tangs, and polish them before they are assembled with other parts to make the completed units.

Molded plastics, on the other hand, are supplied in powder form to firms equipped with injection or compression molding machinery, and are converted thereby into semi-finished and finished parts.

The advantages, of course, to users of cast phenolics, other than those arising from the physical properties of the material, rest in the fact that tool charges are either unnecessary or relatively low, and experimental and production runs may be had with very low set-up costs.

* Catalin Corp.

Lathe and screw machine production

Regular machine shop equipment is used in producing parts from cast plastics. In quantity production of screw machine parts, operations similar to those applied to metals, such as drilling, turning, threading, tapping and milling are performed under conditions involving only differently ground tools, and ranges of feed and speeds adjusted to the requirements of the cast plastic material.

There are few hard and fast rules governing the machining of cast plastics, but it may be said in general that high speeds and light cuts are preferable. Nearly all work is done dry, but coolants of the non-alkaline type may be employed, although rarely required. In producing parts on an automatic screw machine, where the taper common to rod stock may hamper the feed of material, the rods may be had centerless ground to close tolerances and uniform diameter throughout every inch of the entire length.

In turning, tools are sharpened very much as for brass work. There should be plenty of clearance, 18 to 20 deg., and a slightly negative or zero rake is desirable. The tool should be set at right angles to, or one or two degrees above the center of the material. Cutting edges

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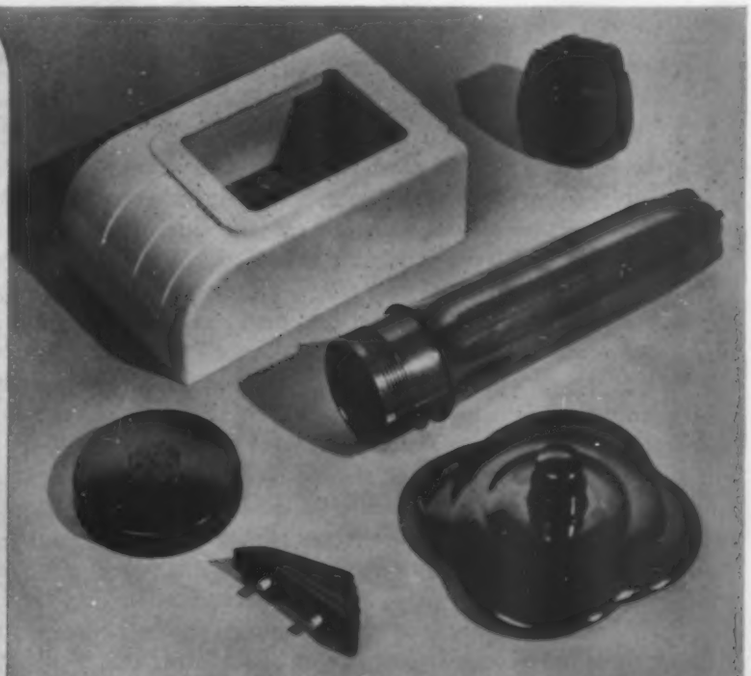

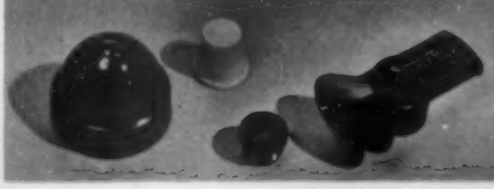

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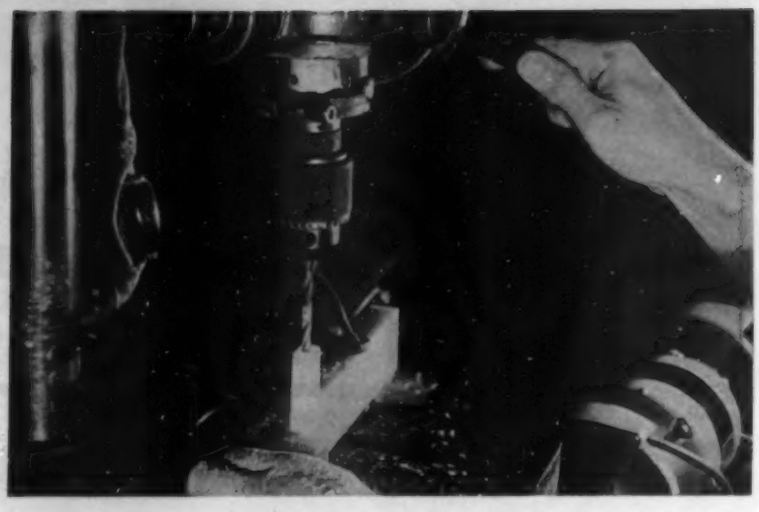
Sawing cast resins may be accomplished by circular, jig or band types of saws, but teeth should be set to permit proper clearance. Twelve hundred to 1300 or more feet per minute are possible



Cast resins may be tapped on vertical or horizontal tapping machines. Standard taps are used and greatest strength is obtained by using fairly coarse threads

should be in condition to produce long ribbon shavings. Tool honing is of advantage for the smoothest cuts. Special grades of tool materials are not required although many hard bronze tools are employed. These have an advantage in that they may be filed without removal from the holders. Stellite cemented carbide or high speed tools may be used when it is desired to get the longest possible runs without frequent delays for re-sharpening or resetting the equipment.

Spindle speed in turning operations ranges from about 450 to 6000 r.p.m., depending on the specific work being done and the diameter of the material, and should be regulated to a surface speed of 600 ft. per minute.

In general fabricating practice, the use of large lathes is avoided wherever possible. Through the application of a little ingenuity operations may be reduced to their simplest form and frequently executed on bench lathes or similar light and flexible equipment. Jigs are of course invaluable in securing fast and accurate production. With tools properly set, sharpened and fed, screw machine or lathe production may go directly into the first stage of the hand polishing or tumbling operation.

Automatic abrasive forming machines

Because of the impracticability of casting rods longer than 21 in., production from automatic screw machines has not reached the high figure attainable with metal. The necessity of having the constant attention of an operator to feed the rods into the machine has acted to reduce the production per operator.

To overcome this feature in automatic screw machine work, forming machines are being widely substituted for screw machines. In the production of balls, beads and what were formerly turned pieces, these machines have no peer. They comprise two stone wheels from 6 in. to 10 in. in length and 4 in. to 6 in. in diameter operating in opposite directions and parallel to each other. One stone acts as a stop and guide and has a flat surface, and the other is formed with diamond cutters to multiples of the shape of the part and acts as a cutter. The rods are cut to convenient lengths, placed in a hopper and automatically dropped between the stones. A flood of water removes the cuttings, cools the material and keeps the stone surfaces from clogging. With the smooth surfaced wheel keeping the material in place and slowly turning it against and toward the cutting wheel, which revolves at a much higher speed, the rods are quickly and smoothly formed into from three to fifteen or more units, depending on their length and the length of the rod.

In this manner, for example, from 350 1 1/2 in. diameter balls to 10,000 3/16 in. diameter balls can be produced

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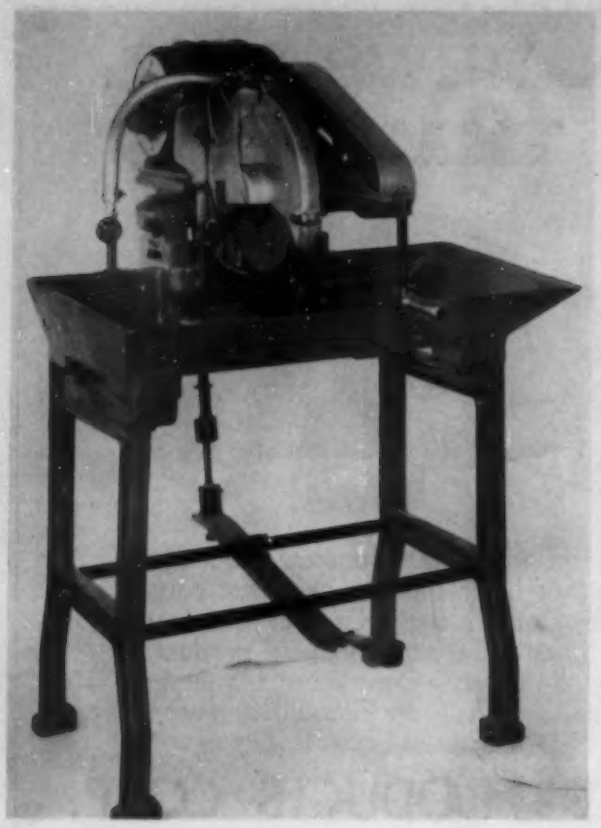

This abrasive cut-off machine slices rods, tubes and blanks of cast resin with a minimum of waste. Buttons, buckle slides and other continuous contour shapes of cast resin are quickly cut into individual blanks in this way

This is a pantograph engraver which cuts letters or designs with a rotating cutter driven by a standard motor. After the design is cut, it is filled in with gold, silver or white paste according to the contrast desired

per hour. Uniformly accurate and smooth production is had with no shut down for tool honing or re-setting.

Drilling and carving

In drilling small holes, drill speeds of about 2800 to 12,000 r.p.m. are commonly used. Drills of 1/4 in. diameter and over should have large flutes for efficient material removal, and cutting edges should be ground with a negative rake.

Turned parts requiring center holes are drilled by means of a turret head attachment, while being turned, whereas odd shaped castings or parts are easily drilled with the usual type of high speed vertical drill.

The material may be easily tapped on vertical or horizontal tapping machines. Standard taps are used, and greater strength is obtained by using fairly coarse threads. Tapped holes should be checked with plug gauges, as the abrasive action of the material is likely to cause wear.

Carving is done with rotary steel cutters fastened to the end of a small motor shaft. Cutters average about 1 in. in diameter and rotate at about 2200 r.p.m. The number of teeth in one-inch cutters is usually 20 to 36.

Portable carving units, similar to that illustrated, are gaining in popularity because of the greater accuracy possible and the substantial time savings effected.

Cutting and sawing

Of all the machines used for cut-off purposes, those employing abrasive cut-off wheels are most widely used. They involve a high speed spindle, to which is fastened the abrasive disk, mounted on a swinging arm on the other end of which is the motor. The weight of the motor acts as a counter-balance, and permits the operator to feed the wheel down into the material. The latter is held in place by hand against adjustable stops governing the angle of the cut and the thickness of the blank. A flood of water on the material prevents scorching and produces a smooth easily polished cut with a minimum of waste. This equipment is used extensively for cutting button blanks and handles from profile shaped rods or slabs.

Most of the cutting disks range from 0.020 in. to 1/16 in. in thickness and from 5 in. to 20 in. in diameter. The spindle speeds range from 3500 to 6000 r.p.m., depending on the diameter of the cutting disks. The rate at which blanks are produced varies with their diameter, ranging from 20 per min. upward to 250 or more.

There is available a hand operated adaptation of the abrasive forming machine for multiple cutting of round and rectangular shaped rods. This machine will cut simultaneously 40 poker chips, 1 1/2 in. diameter by 1/8 in. thick, at a rate of 10,000 per hour. Rectangular shapes, such as mah jong blocks, dominoes, cutlery handles, etc., can be cut ten times faster than with a single blade cutting machine.

Sawing is done at 1200 to 1300 ft. per min. or above. The saw may be circular, jig or band type, and the set of

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Rotary steel cutters fastened to a motor driven shaft are used to carve cast resins. Cutters average about 1 in. in diameter and rotate about 2200 r.p.m. Number of teeth in 1 in. is usually 20 to 36

Hand polishing is usually done on a 2 h.p. double-spindle buffing lathe equipped with soft muslin disks about 12 to 14 in. in diameter. Speed should be about 1500 r.p.m.

the teeth should be just sufficient to permit proper clearance. Best finish results are obtained on a band saw with 14 or 15 teeth per inch. On a jig-saw, the generally accepted blade is a No. 3 jeweler's blade with 22 teeth to the inch for intricate work, and a No. 4 or No. 5 blade for production or stacked work.

Polishing

Cut surfaces have a dull frosted appearance which is easily polished by hand or tumbling processes.

Hand polishing is usually done on a two horse-power double-spindle buffing lathe equipped with soft muslin disks 12 in. to 14 in. in diameter, which run at a speed of 1500 r.p.m. However, any common buffing head with the above wheel equipment may be employed.

The first operation is ashing. This is done with a mixture of oo pumice and water, mixed to a thick paste, which is applied frequently and generously to the wheel and the work. After a few brisk rubs the parts should be thoroughly rinsed in water to remove all trace of pumice. Special polishing compounds or tripoli is applied to the wheel, and after briskly rubbing the part a high lustrous polish is obtained.

To harden the finish and remove any excess polish which may have a tendency to retain finger marks, a final buffing operation on a dry, clean wheel produces the permanently lustrous finish for which cast plastics are famous.

Tumble polishing

In finishing comparatively small articles or large production runs, hand polishing is obviously expensive and slow. Cast phenolics lend themselves admirably to tumbling operations, but because of the presence of important variables concerning the finish of the part, its size, and the degree of polish to be obtained, it is impractical to set forth here formulas covering tumbling operations which can be universally used.

Manufacturers of tumbling barrels and tumble polishing compounds have a service in connection with their activities whereby experimental runs of any type of polishing may be made, and exact formulas covering the proper performance of these operations are submitted by them to the customer, thus obtaining a scientifically correct and uniform finish to tumble polished articles.

Sanding

It is seldom necessary to resort to "sanding" of surfaces of well machined pieces, but sanding can be done on flat or convex surfaces with garnet or sandpaper, which can be used in belt form or in rotating disks. The finer the paper and the slower the cutting, the less pronounced are the abrasive marks. Facets and other surfaces can be cut in this way, but in all cases care must be exercised to avoid over-heating the work, as such "burning" may result in discoloration. The surface speed in sanding plastics is about the same as in wood sanding.

(Please turn to next page)

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Dry tumble polishing is often done in octagonal hard wood barrels operating at 30 r.p.m. from 5 to 12 hrs., depending on the surface conditions of the parts to be polished

Large flat or convex surfaces are frequently sanded with garnet sand paper in belt form or on rotating disks. The surface speed should be about the same as in wood sanding

Cementing

Manufacturers of cast plastics have developed cements for laminating their products, and specifications covering the types of cement available and instructions for using them may be quickly had upon application. In general, it may be said that the cements are simply liquid resins which may be hardened either by the introduction of an acid accelerator or by the application of heat, or by a combination of both.

Fastening cast phenolics to metal shanks

Among their many applications, cast phenolics count handles and knobs one of the most popular, and the problem of permanently fastening the handles or knobs to metal shanks immediately presents itself. However, with a little experimenting a satisfactory solution is quickly obtained. In the assembly of cutlery handles the hole to receive the tang is drilled about .006 in. smaller than the diameter of the tang. The handle is then immersed to the depth of the hole in water, heated to 180 deg. F., and allowed to remain long enough for the immersed part to become thoroughly heated.

While still hot the tang may be easily pushed (but not forced) into the hole and allowed to cool. A permanent grip which will not twist or slip is assured if the tang is knurled. This same principle applies to all shrink-fit assemblies whether tangs, inserts or bushings are used.

Machine and self-tapping screws

Although the manufacturers' cements are the best adhesive to use in laminating cast phenolics, it frequently becomes necessary to fasten metal and other non-porous materials to cast phenolics, in which case cementing is usually impractical.

Several methods of accomplishing these operations are available. In the manufacture of jewelry various metal findings such as clips, catches, and pins must be firmly fastened to the material. Most manufacturers of these articles can supply them stamped with small pointed studs which may be easily forced into the material when it is heated to a temperature of about 125 deg. F. on a hot plate adjacent to the hand or foot press. When the material cools and hardens a permanent grip is assured.

In other instances small hinges, handles, knobs and similar parts are to be fastened to the material. Here drive screws or self-tapping screws may be used to advantage. A hole usually one drill size smaller than the screw is drilled in the material and the handle or knob held in place by driving the screw into the hole. It twists and taps the hole as it enters and once in place cannot easily be removed. (*Please turn to next page*)

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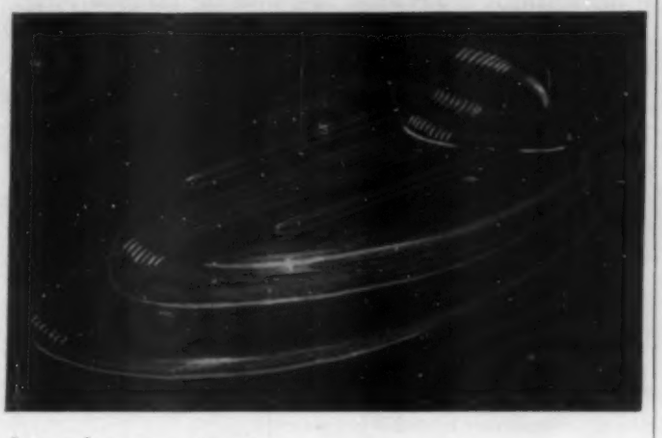

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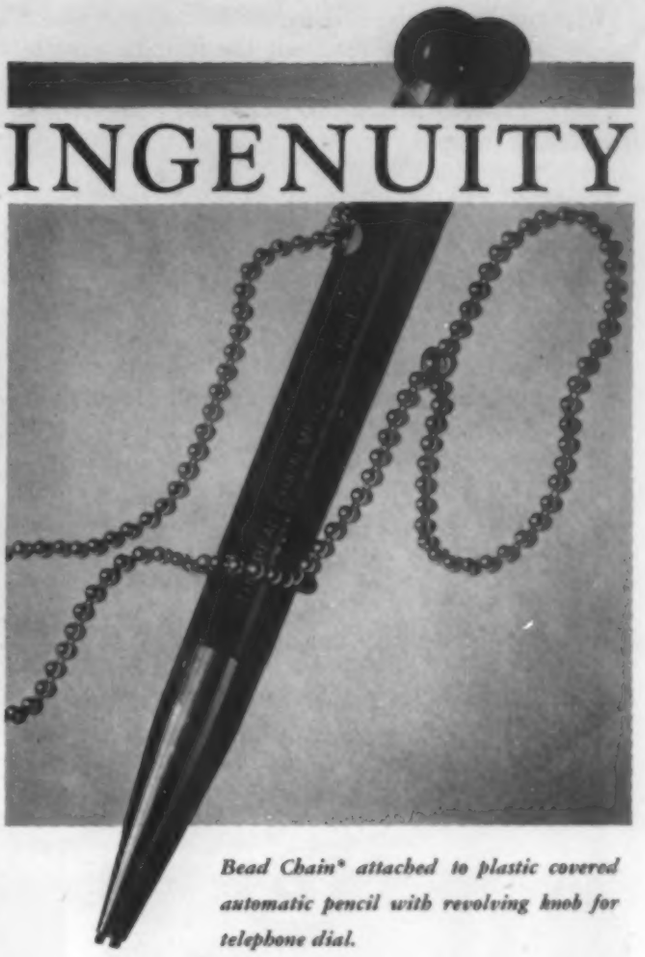

Bead Chain attached to plastic covered automatic pencil with revolving knob for telephone dial.*

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Where the assembly calls for machine screws which on occasion are to be removed, the material may be drilled and tapped much the same as metal, a coarse thread being recommended to reduce the possibility of their being stripped.

Die cutting

Because the material may be secured in a wide variety of special profile shaped rods from which blanks of any desired thickness may be cut or sliced, it is rarely economical to die cut sheet stock. However, when production requirements are too high for jig sawing, and too low to warrant the investment in dipping arbors, die cutting offers a practical solution.

Sheets thicker than $^3/_{16}$ in. cannot be die cut, but for stock of that dimension or thinner, satisfactory results may be obtained by heating the material to about 150 deg. F. and stamping with a steel rule die.

Forming

In general fabricating practice, it is often necessary to curve or shape sheet and rod stock to various radii. Providing the radius is not less than $^1/_2$ in., depending on the thickness of the material, this can be readily accomplished by heating the material to about 180 deg. F. in hot water until it is of the same temperature all the way through, and then placing it over or about the form and allowing to cool. Inasmuch as hot water does not harm the finish, it is advisable to polish the material before forming. It will be noted that the material will expand while at this high temperature, but will return to its original dimensions when fully cooled.

Cast phenolic resins lend themselves to varied decorative treatment such as printing, roll leaf stamping, engraving, inlays, and metal plating which are described in a chapter devoted to these subjects elsewhere in this issue. (See *Applied Decoration*, page 260.)

Small hinges, handles, knobs, etc., may be fastened with drive screws or self-tapping screws as illustrated below at the left. Lower right illustrates how cast resin handles are swaged on tableware. Handles are heated in hot water to the depth of the hole, then the tang of the knife or fork is pushed gently into the hole and allowed to cool. Photograph at the upper right shows the operation of roll leaf stamping on cast resin parts, with a hand-operated press

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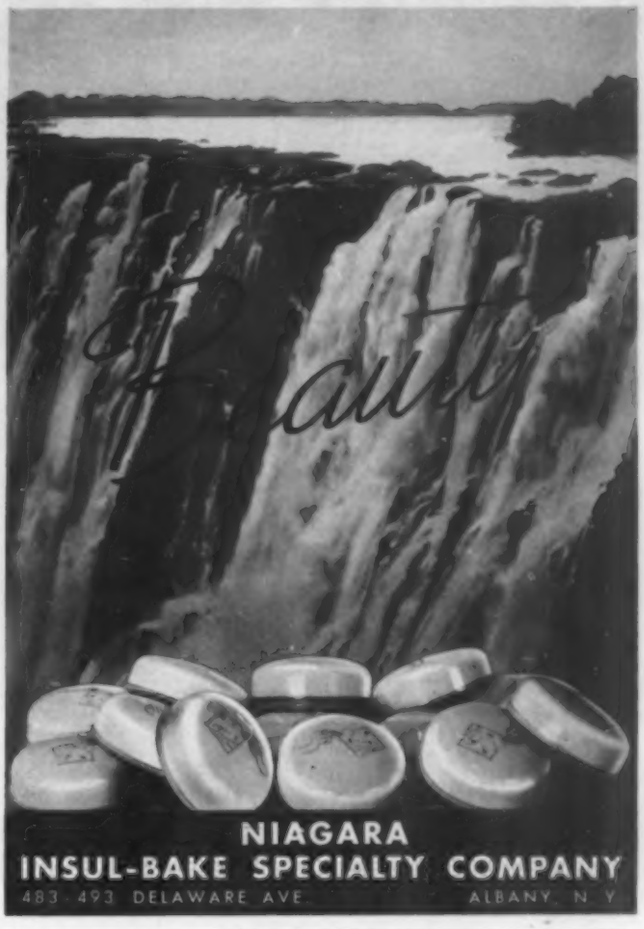

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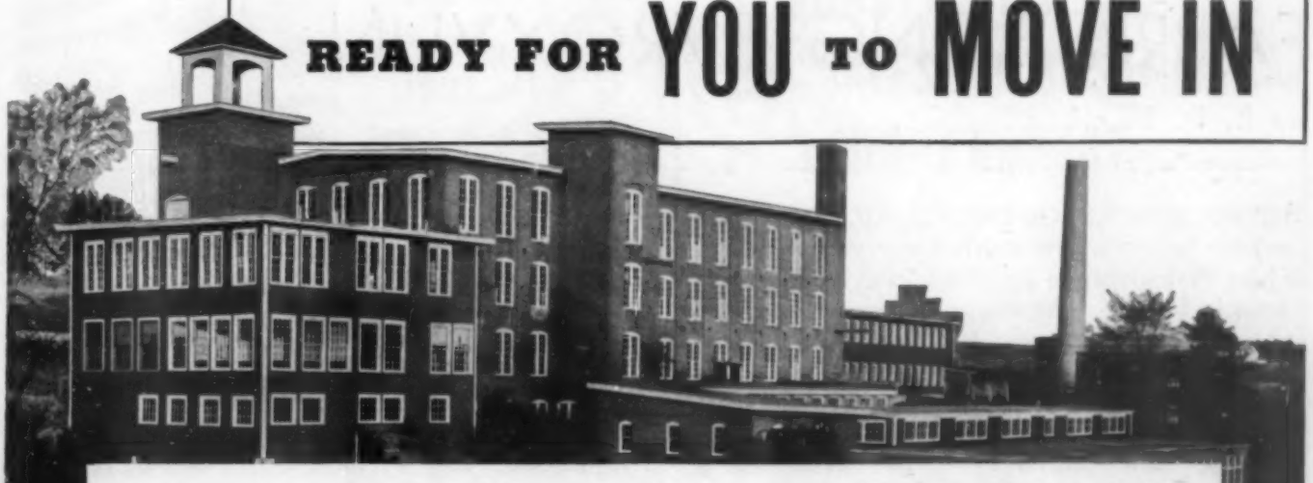

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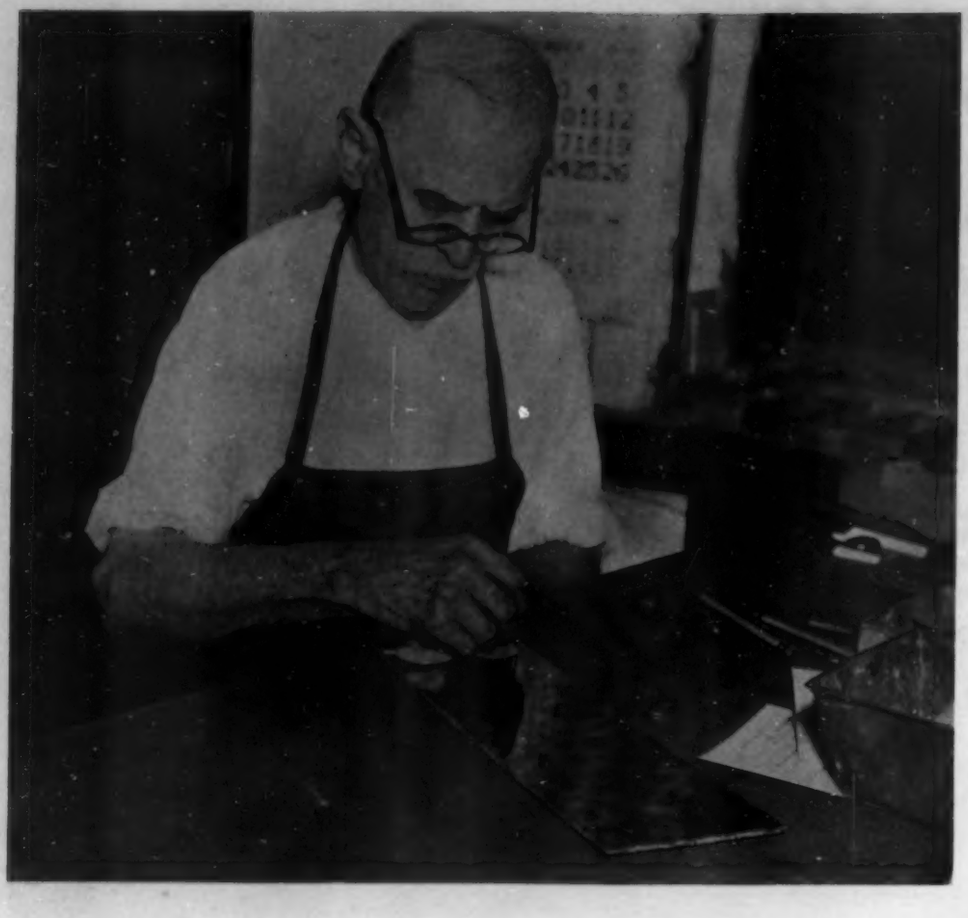

Most pyroxylin fabricating operations begin with sheet stock. Here you see an experienced craftsman laying out a sheet from which spectacle frames will be made. (All photos illustrating this article are by courtesy of Optical Products Corp.)

FABRICATING PYROXYLIN

by R. D. SCHEER*

THE FOUNDATION OF THE PLASTICS INDUSTRY can justly be said to have been laid with the experiments of John Wesley Hyatt in the United States and Alexander Parkes in England, who almost simultaneously demonstrated that a useful artificial material could be made with a pyroxylin base. Almost as old as the plastic itself are many of its applications and methods of fabrication. Probably one of the most interesting collections of the early developments of pyroxylin can be found at the Kensington Museum in London, England. There, on display, are specimens dating from 1855 and onwards, with finished products anticipating many of the present day uses of cellulose nitrate plastics. Among the items shown are an unfinished comb, probably die-pressed, colored buttons, door knobs, one of which is built up of layers of sheet material in variegated colors applied to a purse, carved pieces, a molded green plaque, a letterpress mold and molded and inlaid medallions and figures.

Pyroxylin plastics have come a long way since the early work of the pioneers. Methods of fabrication have been increased and improved, and thousands of new applications developed. In spite of the encroachments of numerous plastics of other types, there was consumed in the United States alone some 10,600,000 lbs. of pyroxylin plastics in 1938. Similar material is made in large quantities in Europe and Japan.

These pyroxylin plastics are essentially cellulose nitrates and camphor, together with suitable coloring ingredients. They are thermoplastic and are produced in the forms of sheets, rods and tubes. They have established and held their place by virtue of a unique combination of useful properties. Pyroxylin plastics may be made in an almost infinite variety of single and combined colors, ranging from a practically colorless transparent through translucent to opaque, possessing beauty in their own right or through the simulation of expensive natural substances such as ivory, tortoise shell, fine leathers, amber and mother-of-pearl. They are light in weight, strong and tough, durable and readily adapted to various methods of fabrication, all properties contributing to wide-spread use. (*Please turn to next page*)

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Optical frames as well as many other products fabricated from pyroxylin require precision lathe turning. This expert workman is turning the groove in the rim which accommodates a prescription lens

This work in the optical industry is called frazing. Any irregularities are corrected by rapidly revolving tools and sandstone wheels which require an adept and experienced hand to guide them

Fashioning the numerous articles which are made from pyroxylin plastics requires a diversity of methods of fabrication. Practically all, however, are merely variations of the two fundamental methods of shaping to which these plastics are particularly well suited, namely, by machining and by the use of heat and pressure.

By machining, when handled with a reasonable degree of care and precaution, pyroxylin plastics can be turned, sawed, drilled, tapped and cut more easily than wood or metal. The material has no grain like that of wood, but machines equally well in either direction, and being softer than metal, can be worked at a high rate of speed. Its toughness tends to eliminate cracking or splitting and makes possible rapid machining, either with the hand tools of the home mechanic or the high speed automatic and semi-automatic equipment of the large factory. Some of the examples of these operations can be found in the fabrication of familiar articles. Many fountain pen barrels and caps are turned out rapidly and accurately by automatic turret lathes. In the manufacture of pyroxylin combs, sawing out the material between the teeth is still a familiar sight. At the toothbrush fabricator's plant, the pyroxylin brush blocks are rapidly drilled and bristles installed and fastened into the holes by automatic machinery.

There are also many other methods of fabricating pyroxylin plastics closely allied to machining. For example, scales for slide rules and rulers are rapidly and accurately engraved by automatic machinery. Huge blanking presses equipped with dies are employed for forming blanks for use in making brush handles and backs, combs and numerous other articles. Carving is frequently practiced in adding a design to a powder box or other articles and where desired, a high polish is

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given the finished product by the use of a rapidly rotating rag wheel supplied with fine abrasives.

The fact that pyroxylin plastics are softened by heat, can be shaped while thus softened, and then regain their rigidity when cooled, forms the basis for the operations of swaging, blowing, and die-pressing. The operation of swaging or forming, as it is sometimes termed, is well illustrated in the making of a soap box. A rectangular blank of pyroxylin sheeting becomes pliable under heat and is then stretched by the closing of a metal mold. Preheating is accomplished by means of boiling water, a steam table or an electric plate. The mold is ordinarily unheated and is closed rapidly in order to shape the material before it loses its plasticity from contact with the cool metal. When the article has cooled to the point where it can be removed without distortion, it is thrown into water to complete its cooling.

Analogous to swaging is the operation of blowing which makes use of the material in sheet form for the fabrication of such familiar articles as floating toys and ping pong balls. By this method, two thin sheets of plastic are preheated and placed between two preheated metal plates containing matched half cavities. The plates are placed under hydraulic pressure and a tiny nozzle is inserted between the sheets through a groove in one plate. Hot air or steam is then forced between the sheets at all points where they are not held in contact by the faces of the mold, causing the sheets to belly out and take the form of the cavities. The whole system is then chilled by dipping in cold water and the finished article removed.

A combination of swaging and blowing is applied to the formation of certain articles which cannot be shaped by swaging alone. One example is a circular container with shoulders, such as a fancy powder box. In this case, most of the vertical stretching is effected by a perforated plunger, after which steam, entering through the perforations, swells the sheet out against the concave mold, which is split to allow the removal of the article. Swaging and blowing are thus used in the production of thin walled articles.

Die-pressing, still another method, is applied to massive articles, and involves merely the change in configuration of a massive pyroxylin blank in a suitable size and in a simple shape approximating as nearly as convenient, that of the finished article. Thus toothbrush handles are made from pieces of sheeting, cut to strips of proper length and width. Thus, too, are combs

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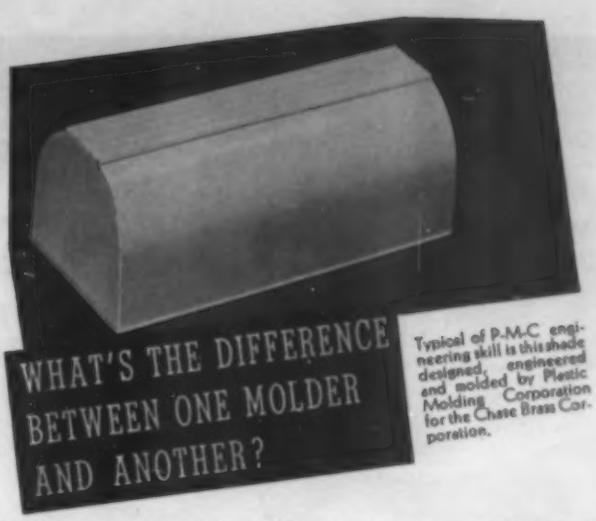

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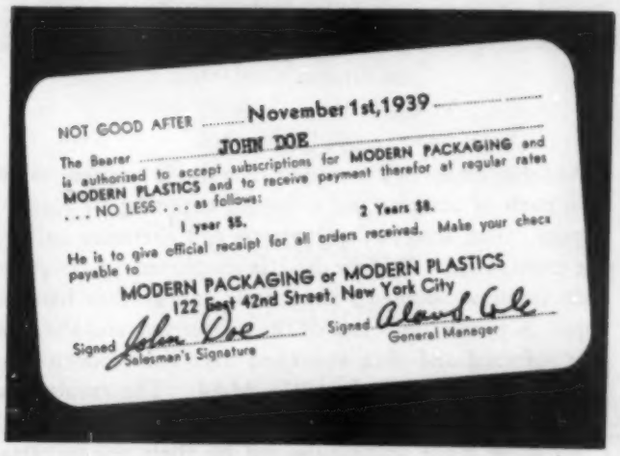

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A rapidly revolving brush-wheel and powdered pumice remove any scratches incidental to production and give a high and lasting luster to the finished piece

Inspection is all-important in any plastics manufacture, especially in the exacting optical industry. Here you see a workman in the plant of Optical Products Corp. aligning the temples and frames before final inspection

pressed from rectangular blanks of the plastic. In die-pressing, two types of dies are employed, one, the flow type, in which the excess material flows out through a split in the die, and the second, the confining type, which receives the exact volume of material, all of which goes into the article being die-pressed. In die-pressing, the blank is also preheated. The die must usually be heated and then cooled, although a few articles permit the use of a cool die.

Another method of working pyroxylin plastics which requires the softening of the material, is embossing. To obtain, for example, a radio panel by embossing, a sheet of pyroxylin is placed beneath a metal sheet containing the desired surface design. To impart the design to the plastic sheet, heat and pressure are applied. After the proper interval has elapsed, the sheets are cooled and the plastic containing the desired design is stripped from the metal sheet.

Another means of softening pyroxylin is by submersion in a bath of acetone and water or exposing to acetone vapors. The acetone is a solvent and therefore softens the pyroxylin. This method is employed in covering such items as women's shoe heels and clothes hamper tops. A pyroxylin blank of the proper size and shape is first softened and then stretched over the wooden heel or cover and cemented at the edges. The result is a smooth, durable and scuffless covering.

By these main techniques and by their slight variations to suit the particular job, are produced the multitude of articles to which pyroxylin plastics impart utility, durability and the beauty of color and pattern inherent in the material. Though it is a veteran in the field, modern designers, familiar with the capabilities of pyroxylin, are constantly developing new applications, thus assuring the continuance of pyroxylin as one of the mainstays in the plastics industry.

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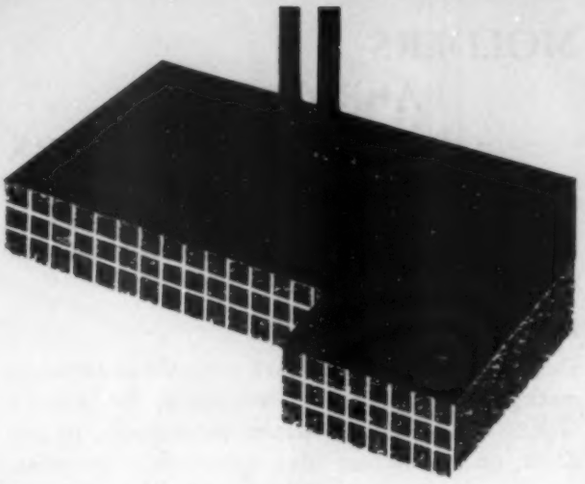

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Many small shapes and a wide variety of plastic materials can be successfully processed on an automatic press. These were produced on the F. J. Stokes press pictured on the opposite page

AUTOMATIC PRESSES

by EDWARD S. WALKER and G. W. GLENN*

THE PAST YEAR HAS BEEN A PERIOD OF RAPID development in automatic molding methods and equipment. It has brought announcements of new automatic compression molding presses by at least two equipment manufacturers. It has reported several other press developments which are still in the more or less experimental stage and details about which are lacking. It has witnessed the addition of full automatic controls to a standard compression press arranged to make its own preforms and feed them to the mold automatically. It has brought to public attention some details of an injection molding machine designed to handle thermosetting materials as well as thermoplastics.

The year also has seen the press manufacturer who, less than two years ago, was first to enter the field with a completely automatic compression molding machine for thermosetting materials expand his original machine into a line of several models and sizes, greatly increase their production capacity, develop models to handle either or both thermosetting and thermoplastic materials, feed certain of the so-called impact materials automatically and otherwise step-up both the size and variety of work that can be handled and the efficiency of the press equipment with which to mold it.

The effort and money being expended to further perfect and develop automatic molding methods is hastening the day when the mass production of molded plastics, of almost infinite variety, will be so economical that innumerable new applications will be found and plastics will in reality become the material of a million uses.

Facts and figures made available for this article, show that the time has already arrived when manufacturers

* F. J. Stokes Machine Co.

can no longer afford to overlook the demonstrated economies and other advantages of automatically molded plastics as substitutes for castings, stampings, die castings, finished wood turnings, parts machined on automatic screw machines or fabricated by other methods. A great variety of such parts are being molded automatically at costs astonishingly low by comparison with former methods.

These automatic molding machines have greatly improved the competitive position of plastics, have made the molding of plastics independent of skilled operators, improved the dielectric strength and physical properties of finished parts by doing away with errors of human omission or commission. They cut flash losses and do away almost entirely with finishing and inspection operations that were formerly necessary. They make it possible to obtain large output from inexpensive single-cavity molds and thus hold the initial mold investment to a point so low it is profitable to mold plastics even in limited quantities and for purposes where they never before have been economical. And because initial mold cost is low it is easy and practicable to change design in an automatically molded product as often as may be advisable and at little expense. Inventories can likewise be kept low.

In automatic molding unit costs are determined largely by the initial investment in the mold, the cost of material used and the cost of power for operation. Further along in this article will be found figures on production costs of automatically molded parts that have come either from shop records of users of automatic molding machines or were compiled by engineers of the press manufacturer from test runs made with machines and molds set up to produce the parts mentioned. Before presenting these figures, however, descriptions of several automatic compression molding machines, recently announced, should be of interest.

Standard automatic molding press

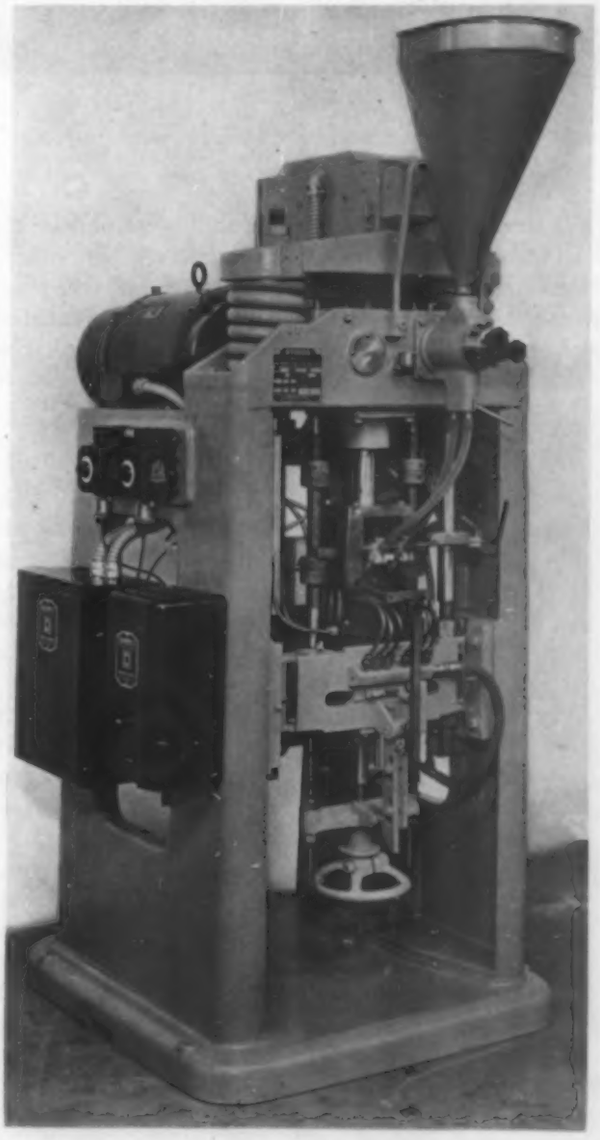
This compression molding press, built by Standard Machinery Co., is self-contained, entirely automatic in operation, designed to use multi-cavity molds and give low molding costs for large production runs. It performs all the operations of routine molding including preheating the powder, loading it into cavities, closing and opening the mold for gassing and curing, ejecting the finished parts, blowing flash from the cavities and forces. The cycle repeats with no manual attention necessary other than to keep a hopper filled with molding powder. Molds are protected from the possibility of double pieces being molded and from resulting damage and costly repairs.

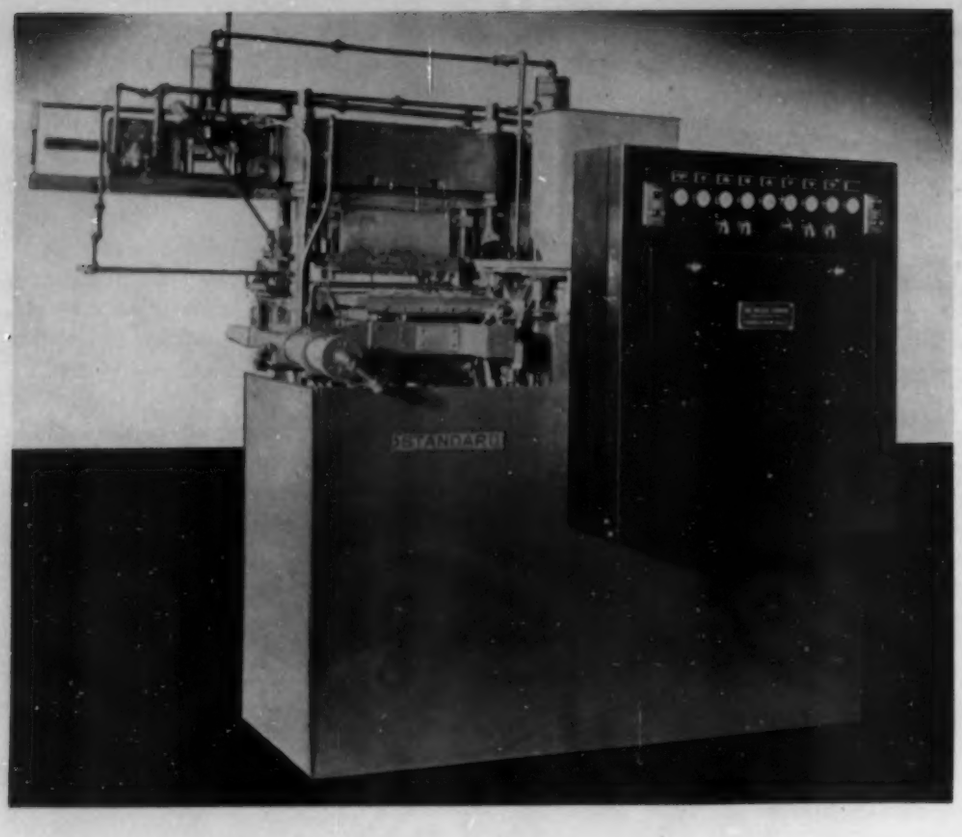
The press is so designed that the ejecting, cleaning and loading of the mold is done outside of the press cycle. Two sets of molds are used. While one mold is under pressure during the cure, the other mold is outside the platens of the press, the upper mold to the left and right of the head of the press alternately and the lower mold moves to the front and back of the press bed alternately. With this construction, the remaining time of the press cycle, outside the curing period, is the time required for the press to open, the molds to shift position and the press to close, all of which requires about 13 sec. with a 6 in. stroke of the ram. Hoppers are arranged on the front and rear of the press and the cavities of each mold are filled alternately from these hoppers by means of an automatic loading board.

In tests made with a 28-cavity mold for attachment plug caps, the press operates continuously on a 55 sec. cycle which includes 13 sec. for opening and closing the press, 7 sec. for gassing, and the remaining 35 sec. for a perfectly timed cure.

The 56 cavities for this test were taken from a mold in a 50-ton press, manually operated. Production increased through a shorter time cycle and quality of the work improved with highly uniform dielectric strength and physical properties in molded parts. (*Please turn to next page*)

Stokes completely automatic molding machine has 15-ton capacity, with dual feed and individual powder measuring device to each cavity. Output is reported at 13,440 moldings per week





The new Standard automatic self-contained press for thermosetting materials. While one mold is under pressure, another is outside the platens, being recharged for its next pressing. This press is operating at Bridgeport Moulded Products, Inc., and is available through F. J. Stokes Machine Company

The multi-cam cycle controller on this press allows the timing of each operation independently of the others. However, the only change necessary to make in going from one mold to another, is in the preheating, breathing and curing periods. The curing time is adjusted separately by a microflex reset timer with a range from 2 seconds to 4 minutes.

Stokes completely automatic molding machines

During the past year the F. J. Stokes Machine Co. has done a large amount of research and development work to broaden the range of automatic molding, adapt automatic methods to special applications, make it practicable to automatically mold materials other than free-flowing granular powders and further increase press output and lower production costs.

The company has added to its line a number of new models, including a larger press, with 10 in. max. stroke, to mold parts up to 4 in. in height or 6 in. in length and with projected area up to 19 sq. in. These machines are now available in both thermoplastic and thermosetting models, with steam or electrically heated platens, for rated pressures of 10 tons and 15 tons. Models have been developed with double and triple feed and measuring devices for feeding materials of differing type or color or feeding powder into two or three molds mounted on the same platen; for feeding special materials with high bulk factor; with unscrewing devices by means of which parts molded with threads may be unscrewed and ejected automatically; also for molding parts with side-draw.

Saving obtained by automatic molding

These machines automatically measure out and charge the mold with the required amount of powder, close the mold for plasticizing, open for degassing, close for curing and then open, eject and discharge the finished molding at the same time the mold is being blown out and the following charge is being measured out. Each step of the cycle and its duration is timed and controlled to the split second. Uniform physical properties and dimensions of molded parts are assured, because the time, temperature and pressure are automatically maintained constant for each curing period.

These machines have been in service in many plants for lengths of time sufficient to have developed much interesting data on automatic molding costs compared with conventional molding costs on identical parts and quantities, also costs of parts fabricated by die casting, stamping, etc., as compared with costs of the automatically molded parts which replaced them.

The following "case histories" have been boiled down to the bare facts purposely for the sake of brevity; but authenticating data is available in every instance. A toy manufacturer substituted an automatic molding for a die casting and savings paid the entire cost of the press, mold and installation in 100 days. A novelty manufacturer saved 58 percent, obtained a much finer finished and stronger product when he replaced wooden turned and painted parts with automatic moldings. One electrical manufacturer cut the cost of moldings

from one cent each to approximately one-tenth cent. For the price he would have paid for the 50-cavity mold recommended for conventional molding practice, another electrical manufacturer bought and paid for an automatic machine and a four-cavity mold which gave parts in sufficient quantity for his production requirements.

Many equally good examples could be cited, but perhaps one of the most outstanding is the case of an aluminum part, turned in an automatic screw machine, at a shop cost of $76.00 per thousand. It was found that a plastic molding, equally satisfactory in all respects and superior in some of its qualities, could be produced at $12.00 per thousand. Then there's the case of a toaster leg, automatically molded four at a time in a sub-cavity mold, at a shop cost (no overhead) of $1.70 per thousand. The former cost of this part was $15.00 per thousand.

With automatic molding, parts can be produced in practically any required quantities, large or small, at low costs. Since the machines require no operating attention, they are run continuously, 168 hours per week, and output is high even when a single-cavity mold is used, and proportionately greater, of course, as more cavities are included in the mold. With a 60 sec. cycle, for example, (and many parts can be molded automatically in less time) output of one cavity is 10,080 moldings per week. With a four-cavity mold on the same job one million parts can be produced in 173 days.

The highest known output so far attained by a Stokes machine is in the plant of a toy manufacturer who, using a sub-cavity mold for 19 pieces, is producing a million moldings in approximately 35 days.

Watson-Stillman automatic compression molding machine

This machine, introduced in July of this year by the Watson-Stillman Co., is an automatic, self-contained press in which either loose granular materials or preforms are fed into a hopper and the various operations of the molding cycle are performed without manual attention. It consists primarily of two hydraulic cylinders, one vertical, one horizontal; also feed and ejector systems automatically timed to function in proper sequence.

The machines are offered in 25-ton, 50-ton, 100-ton and 150-ton capacities and while they are designed primarily for thermosetting materials, it is reported that thermoplastics may be molded as well.

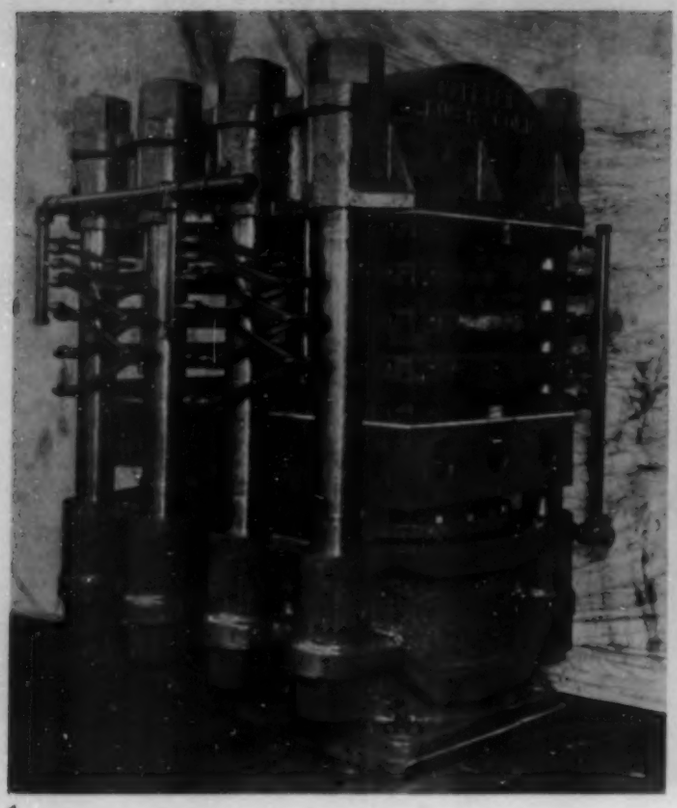
It is claimed that any type of die may be used—flash, semi-positive, positive or split; in single or multiple cavity with one or more rows. Split dies are used without special handling and may be mounted in a vertical or horizontal position. Adjustable stripper rods are provided on both vertical and horizontal cylinders. Pressure on cylinders is adjusted independently.

Boonton's "robot" press

Boonton Molding Co. has built a "robot" press in which preforms are made for each individual mold cavity, preheated to reduce curing time and then fed to the mold of a standard 200-ton press which is fitted with full automatic controls. The preforms travel to the main press in conventional-type loading trays, the press performs the complete molding cycle in the usual manner and finished parts are ejected automatically. Bottle caps molded on this machine are said to have 15 per cent to 20 percent greater strength, production costs have been considerably reduced, rejects have been cut to less than $^1/_{10}$ of one percent and flash losses have been reduced. This machine was put into service by Boonton in April of this year.

Automatic machines at present available have contributed to the ever increasing use of plastics. They reduce to the minimum the initial investment required to produce moldings, cut unit costs on a wide range of work, put plastics in a better competitive position than ever, and make it profitable for many manufacturers to use plastics instead of other materials which have heretofore held a price advantage. Newer machines are now coming along to extend the range of work that can be handled automatically, to do away with human error, improve product quality and further lower costs in the production of parts which may be molded more economically in larger presses and multiple-cavity molds.

The Watson-Stillman side-ram press pictured here is fully automatic with a horizontal opening between plates of 19 in. (25-ton capacity) and 22 in. (50-ton capacity) with a vertical opening of 21 in. and 23 in., respectively. The oil reservoir and pump are in the base. It is capable of turning out complicated parts without human attention



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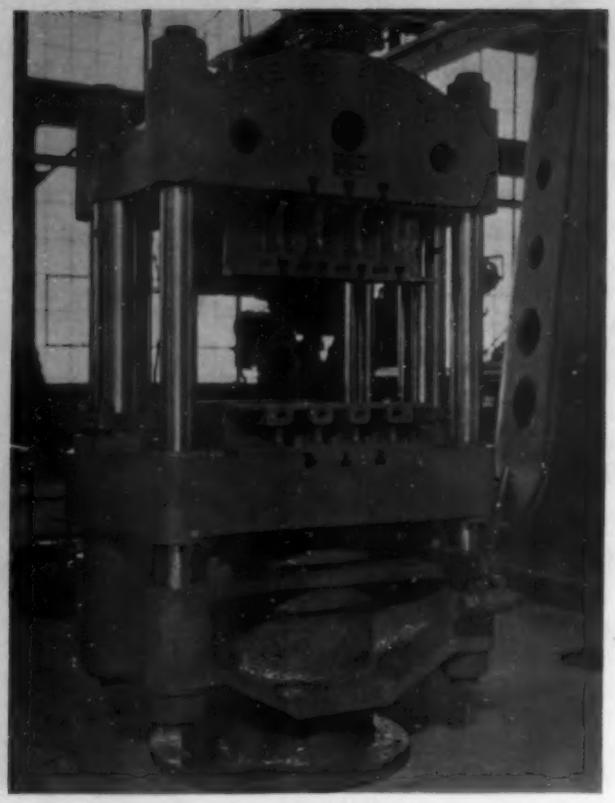

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Laminating presses (Fig. 1) are equipped with a series of platens so that a number of sheets of material may be pressed at once. Rod-type semi-automatic presses (Fig. 2) are used for conventional compression molding. Both presses pictured are made by Lake Erie Engineering Corporation

COMPRESSION PRESSES

by H. D. THWEATT*

A COMPRESSION PRESS MAY BE DEFINED AS A DEvice which applies pressure to plastic material either in a mold or between plates causing it to be cured to a definite size and shape. The necessary heat may be applied directly to the chaneled mold or indirectly through the steam plates of the press.

The simplest form of a press consists of a hydraulic ram and cylinder tied to a resisting member or head by means of four rods. This general design has many variations both as to size and shape.

Products

Compression presses have two general divisions as to the type of work done, namely, laminated plastics of the sheet or slab type and, secondly, parts molded to a definite shape.

Laminating presses

These are usually of the multiple opening type having several steam platens between the fixed head at the top and the ram bolster and moving platen at the bottom. The sandwich or layers of impregnated material are placed between the platens and the pressure applied by ram or rams. Steam is passed through the drilled holes in the platens giving the proper heat for curing. Usually suitable loading devices called elevators, are used to raise and lower the material to the proper opening in the press. This type of press, however, because of its special nature represents only a small percentage of the total of compression presses used.

Compression presses for molded parts

These may be classified or divided into several different types, depending upon the nature and quantity of the molded parts to be produced, the principal divisions being:

A. As to operation, including hand-molding, semi-automatic, and fully automatic.

B. As to design, such as rod-type or side-plate-type.

C. As to source of hydraulic pressure, i.e., from a central accumulator or pressure from a self-contained hydraulic pump.

* Lake Erie Engineering Corp.

Hand molding presses

These are generally small, not over 20 in. by 20 in. in size and almost entirely of the four rod type. Sometimes they are multiple opening but usually of one opening only. The mold is separate from the press and is loaded and unloaded on the outside and then placed between the steam platens of the press. The heat for the curing of the material passes through the body of the mold from the steam platen. This type of press is used for experimental and laboratory work and for small quantity runs where the cost of a more elaborate multiple cavity mold is not justified.

Semi-automatic presses

Perhaps most generally used of all of the compression type, they are almost entirely of the upstroke type arranged with strippers at the bottom and sometimes at the top for the proper ejection of the finished piece. The two halves of the mold are mounted on bolsters and parallels, so-called, which separate the mold from the platen proper for stripping purposes. The mold itself is arranged with ejector pins which project through the bottom of the mold and bear against suitable cross knockout strips which in turn bear upon the knockout bars of the press. When the press is open, these knockout bars are actuated by means of either auxiliary hydraulic cylinders or by means of knockout pins which bear against the top of the cylinder on the end of the down stroke. A similar arrangement is sometimes provided at the top in order to obtain top stripping as well.

The semi-automatic press is always equipped with pull-back cylinders or other forms of return mechanism as it requires considerable pressure at times to separate the two molds and eject the finished piece.

Automatic presses

A comparatively recent development, they are still comparatively small in size, that is, with a few cavities. These have not only the regular features of the semi-automatic press but also automatic loading and ejection devices so that it is only necessary for the operator to keep the hopper full of the molding material. We believe that you will see considerable further development in this type of press in the near future in order to compete with the high production of the injection molding type press now used for thermoplastics.

Rod-type molding presses

This type is the most universal in use at the present time and has been used since the beginning of the curing of plastic parts.

These usually consist of a ram and cylinder at the bottom tied to a top head by means of four tension rods and nuts. The ram carries a moving platen which is guided on the four tension rods. Both the top platen and the moving platen are arranged with bolsters and parallels as described above having "T" slots for the proper fastening of the two mold halves. Knockout bars are arranged on both sides at the bottom and sometimes at the top to facilitate removal of the part. (*Please turn to next page*)

Here is a 390-ton angle press (Fig. 3) built by Baldwin-Southwark Corp. and a 450-ton semi-automatic compression press (Fig. 4) with fully enclosed hydraulic power unit built by Watson-Stillman Company

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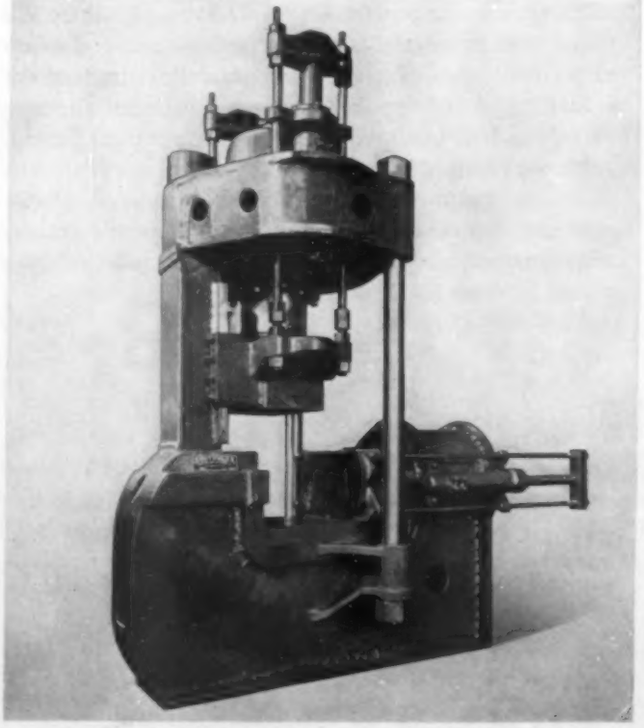

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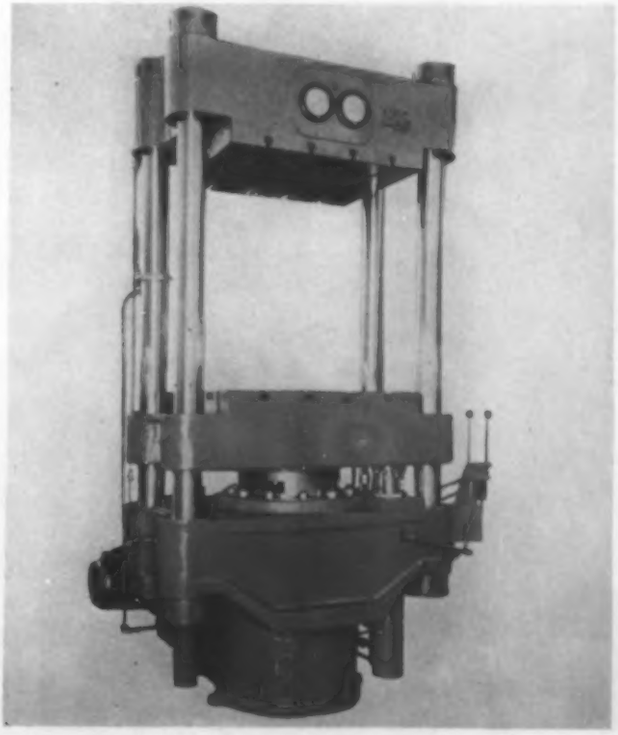

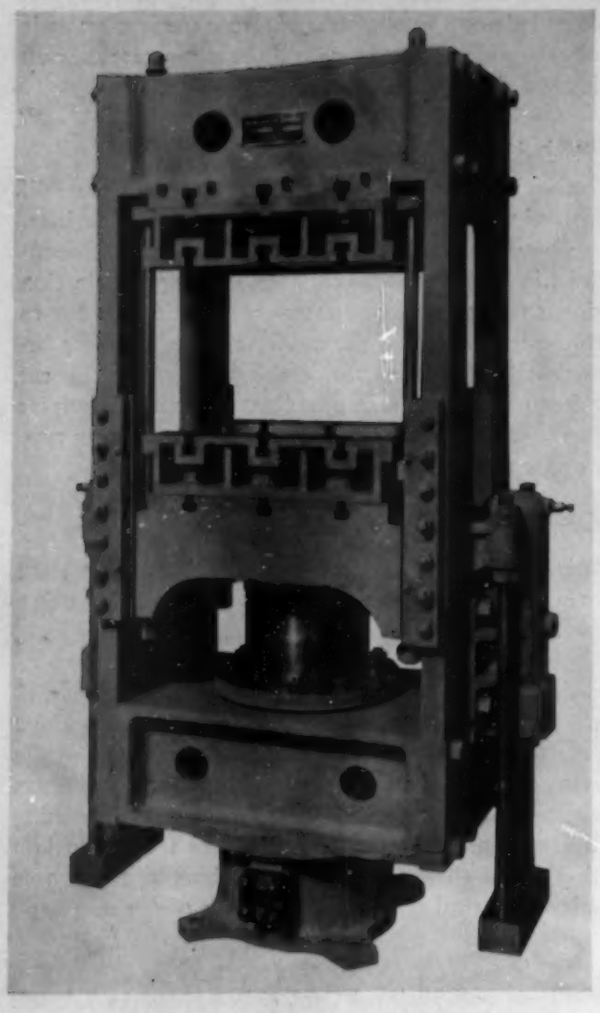

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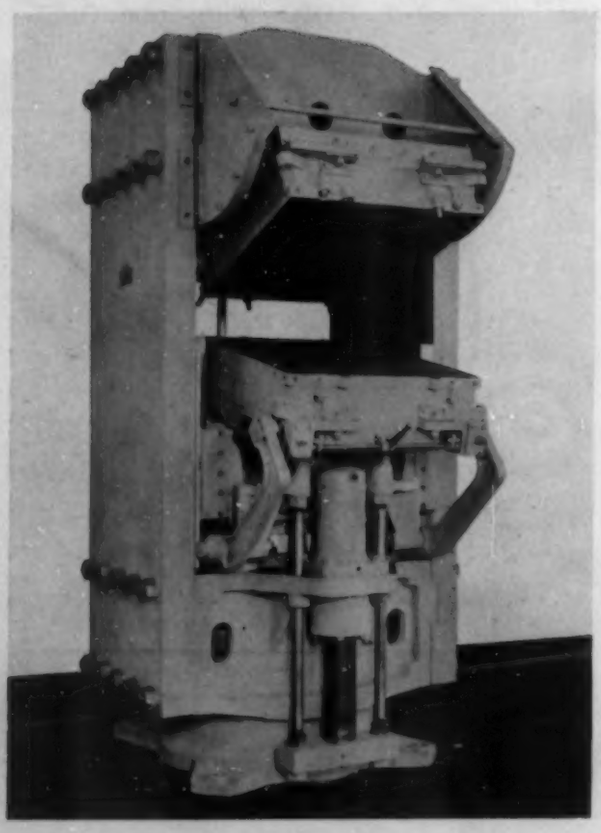

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Side-plate type molding presses

This is a more recent development in design which has been occasioned by the demand for greater accuracy in guiding and also for a neater, more streamlined appearance of the press itself. Instead of using four round rods for holding the cylinder to the top head, two rolled steel side plates of homogeneous and uniform material are used. Large substantial keyways are machined in these plates and corresponding keys in the cylinder and top head to take care of the tension. These side plates are securely bolted to the top and bottom members and, if properly designed, present the same effect as a solid housing.

The most valuable characteristic is the use of the gib guides which are fastened to the moving platen and bear against suitable machined surfaces on the side plates. These are usually adjustable allowing takeup for wear, enabling the operator to keep the guiding of the moving platen accurate at all times. In order that there may be no binding or loosening of the guides when the press is heated up, it is customary to develop a certain angle of the guides so that the heat expansion will cause the gibs to slide along this surface instead of binding or opening up. The advantages of this type of guiding are quite obvious. On the older type of presses it is custom ary to use extra large dowel pins or guide pins in the mold s in order that proper registration may take place. With the side-plate or gib guide type of press, it is possible to use smaller dowel pins and also relieve the wear on the pins themselves. On the older four rod type of press it is customary to use babbitt guides which require complete replacement when they become worn.

At first there was some criticism that the steel side plates shut off the accessibility of the dies on each side but this has been taken care of by cutting suitable openings or windows in the side plates. This still leaves sufficient tension area in the plates to take care of the load.

Another variation of the side-plate type is where the rolled steel plates are used front and back instead of on each side. These plates are cut out in the center and the cylinder and the top head mounted between the two plates and bear against the edge of the cut out opening. It is then possible to cover over the two plates with suitable sheet metal giving a complete streamlined appearance and this is especially adaptable where the press is self-contained with its own pumping unit which can be placed between the two plates.

Fig. 5 shows a side-plate molding press with rigid housing and no tension rods. The moving platens are guided by four adjustable gibs which give maximum accuracy of both movement and pressure. Fig. 6 shows a side-plate tilting-platen type press. Both presses are by Lake Erie Engineering Corporation

Hydraulic pressure supply

All hydraulic plastic molding presses were originally operated from a central accumulator and pumping system as there were no modern rotary oil type of pumps available. The accumulator generally consisted of a weighted tank, that is, with ballast hanging on a ram, having the proper size to develop the correct pressure. This accumulator or reservoir was pumped up by means of a triplex or three plunger pump and sometimes by means of a steam pump. This accumulator was designed to have sufficient capacity to take care of several presses opening at the same time and the pump had a capacity to handle the total number of presses opening and closing within a definite period of time.

In some cases a two-pressure system was used, that is, a low pressure for rapidly closing the press and then a high pressure for the actual final pressure. Three thousand lbs. per sq. in. were generally used on the accumulator type of press, but this varies from time to time.

Self-contained presses

This is again a more recent development which has become more universal throughout the trade especially with those molders who are making parts for their own manufactured products. This type of press is unquestionably most desirable when only one or two units are required and it is a question of economics as to when the design should change from the self-contained type to the accumulator type.

The hydraulic press manufacturer has a number of pumps available for the operation of these presses. Some of these are of rotary-piston type where an eccentric action of a ring carrying the plungers generates the desired flow and pressure.

There is also the rotary-vane type of pump consisting of a series of vanes operating in an eccentric ring to develop the required pressure supplied. Both types have been used successfully by various manufacturers.

One of the advantages of the self-contained type is that individual presses may be run individually without having to run a complete accumulator system. This also avoids long hydraulic lines from the accumulator and pump to the presses with the accompanying high cost of maintenance for such equipment.

In some few cases presses have been equipped with a

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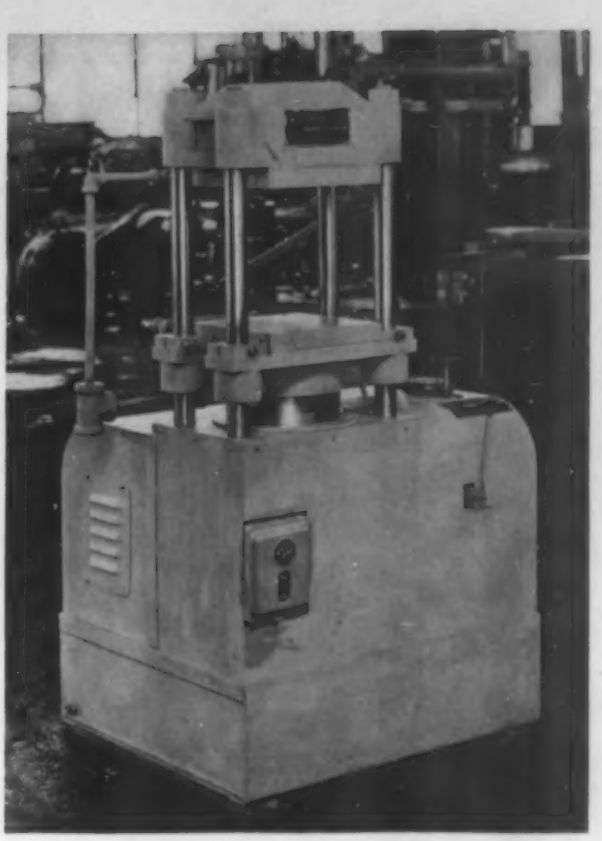

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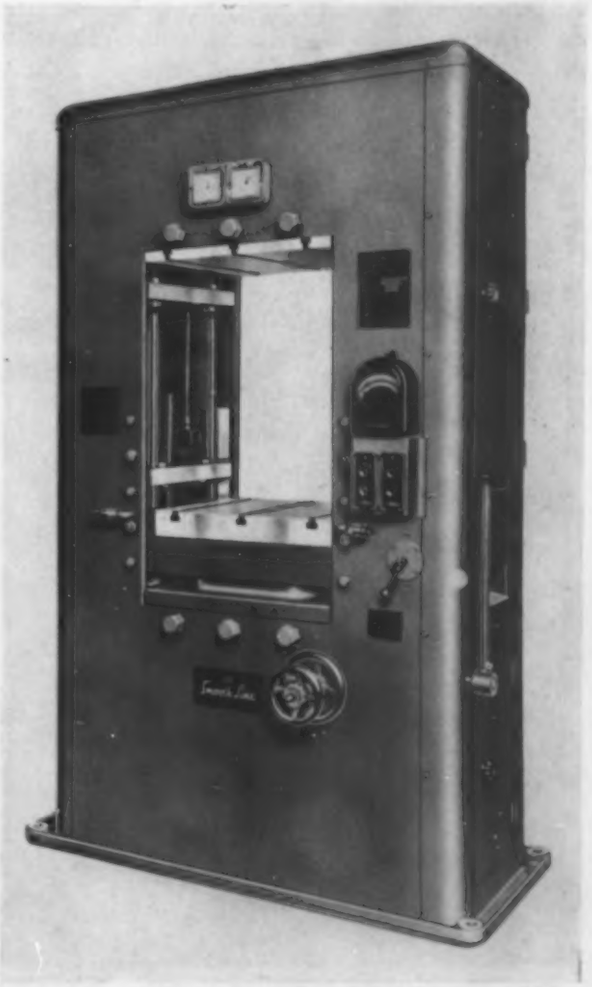

Fig. 7 is a self-contained hand molding press by Lake Erie. Semi-automatic presses with self-contained hydraulic systems are growing in popularity. Fig. 8 shows such a press made by Hydraulic Press Mfg. Co. which is available in upward and downward acting pressures

hand pump where it was not economical to install either a self-contained motor driven pump or connect up to an accumulator line.

Miscellaneous types

In addition to the standard types noted above there are also several special types of presses one of which is the angle molding press. This was originally developed for molding angular pieces and the press has a vertical and also a horizontal ram. This type of press can also be used for recessed dies that cannot be split vertically alone. In other words, the die can be made of the three part type using the two rams to close the side and the top. This type has also been used for simplified injection molding, that is, by using the side ram to close the die and then mounting a plunger on the vertical ram to force the material into the mold.

Another special press for compression molding is the tilting-head type which was originally built so that the whole top head tilted back after the ram had dropped down, allowing the operator to get at the bottom and top molds more readily for unloading and cleaning. A still later development of the tilting-head type or rather of the tilting-platen type is where both the top and bottom platens move out the front, at the same time they are tipped giving still greater accessibility to the molds. These are also equipped with automatic stripping or ejecting devices.

Another variation of the compression molding presses is the toggle type. Instead of a straight hydraulic ram pushing up against the bottom platen, there are interposed a set of toggles so that the ram itself can be operated under low pressure and through the toggles increase the force of the pressure against the platen. Another variation of the toggle press is where no hydraulic ram is used and the action is mechanical by means of an electric motor directly driving the movement of the toggle.

Operation and controls

The simplest form of control on accumulator operated presses are the hand operated valves which are generally of the screw stem type. The operator merely closes the exhaust line with the turn of one valve and opens the pressure line with the other, causing the press to close and build up to the required pressure. Similarly, where heating and cooling were needed the steam and cold water valves were manually operated.

With the introduction of the self-contained press it was possible to obtain not only quick and accurate control of the movement of the ram, *(Please turn to page 313)*

Self-contained molding press (Fig. 9) with fully automatic timing control for both the press cycle and the steam and cold water cycles, built by French Oil Mill Machinery Co. Fig. 10 shows a Greenerd arbor press, equipped with automatic electric time cycle and ram control

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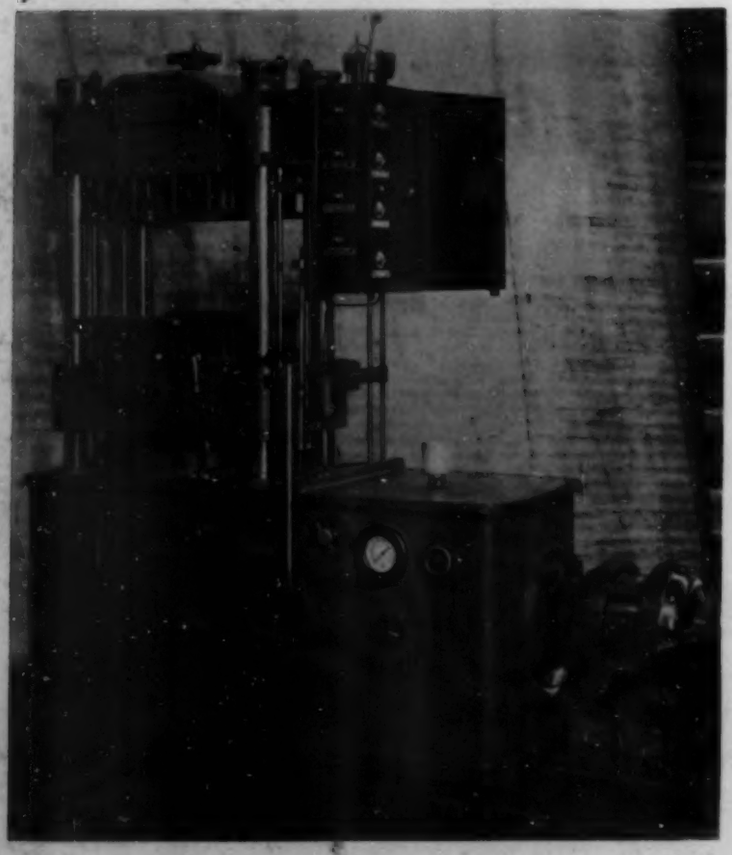

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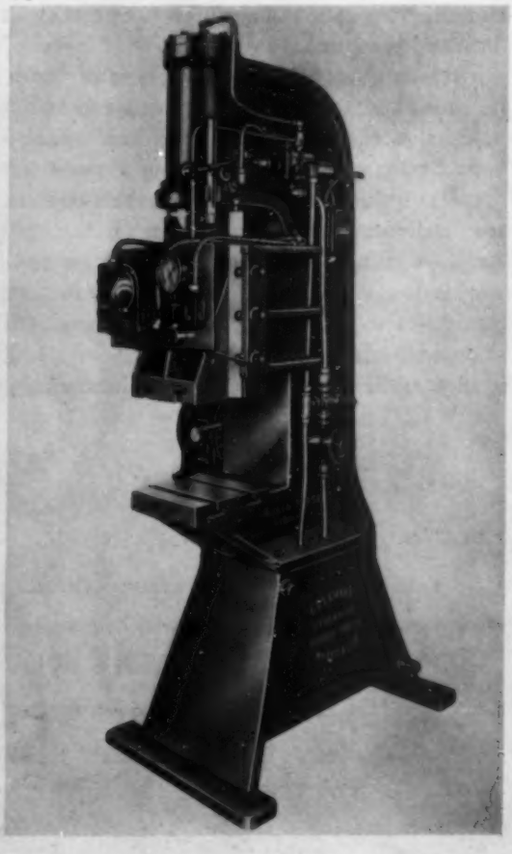

HPM

INJECTION MOLDING PRESSES

BULLETIN NUMBER 3909

NEED FOR THE MODERN PLASTIC MOLDER

ALL-HYDRAULIC
INJECTION MOLDING PRESSES

Hydraulic power – directly applied – is emloyed for every pressure action in each of the H-P-M designs of plastic injection molding machines. This provides the molder with extreme flexibility of operation and ease of change-over from one job to entirely different ones. Every function of injection molding is performed by H-P-M machines in a manner that is distinctively H-P-M. In sequence these are as follows:

H-P-M POSITIVE MATERIAL FEED – A torque motor driven feed mechanism delivers the granular molding material to the injection chamber. All units of more than two ounce capacity have an enclosed force-feed, providing positive delivery of large quantities. Feeding is automatically proportioned to plastic output.

H-P-M FLUID-HEATED INJECTION CHAMBER – A circulating fluid, heated electrically by immersion elements, transfers the heat to the material in the injection chamber. This system has proven through extensive practical application to provide positive and accurate control of temperature of the plastic. Tests show very uniform heating. Temperature is stabilized by this H-P-M Fluid Heat Method through the equalizing effect of a volume of liquid – overruns are avoided. Plastics of delicate tints are readily handled without burning.

H-P-M HYDRAULIC-LOADED INJECTION NOZZLE – Positive connection between the injection chamber nozzle outlet and the mold inlet is provided by direct hydraulic means. No mechanical adjustments are required. The loading on the nozzle is uniformly maintained. The nozzle withdraws slightly automatically at the end of each cycle, breaking the sprue. For access to the nozzle a wide separation can be quickly obtained.

H-P-M DIRECT PRESSURE HYDRAULIC CLAMP – The H-P-M method of clamping the molds by direct straight line hydraulic action possesses the following distinct advantages:

1 – Clamping force applied directly over the mold.
2 – Clamping force definitely known and under positive control.
3 – Very few working parts, and these are extremely simple.
4 – Very small friction of moving parts, resulting in high efficiency.
5 – No load on pins, joints, links or other parts subject to wear and failure.
6 – Rapid closing and opening of clamp.
7 – Absolutely smooth movement, free from shock. Important when inserts are used.
8 – Variable daylight opening, requiring no fine adjustment.
9 – Clamp always automatically adjusted to mold of any thickness.
10 – No adjustment of clamp required when changing molds.

Every molder who uses H-P-M machines realizes the importance of the last named feature. Adjustment for molds of various thickness is not required in a straight hydraulic clamp. Where a toggle clamp is used a careful adjustment is necessary for each mold. A slight error in adjustment may result in damage to the mold and there is no way of definitely regulating the clamping pressure.

H-P-M VARIABLE CAPACITY RADIAL PUMP DRIVE – Each H-P-M injection machine is provided with separate hydraulic power units for the direct hydraulic clamp and each injection unit. The radial type pump provides a constant pressure against the clamp ram with a very minimum power consumption, due to the variable volume feature. An automatic control regulates this according to demand – maintaining the output near zero when the ram is stationary while holding full pressure on the molds. Automatic follow-up of full load is accomplished by this same control. No chance for mold flash – the pressure is always right there. No waste of power as with constant volume pumps which must dissipate full horsepower through relief valves.

H-P-M – THE COMPLETE LINE – a size for every molding job. H-P-M, the pioneer producer of injection machines in America, offers a line of machines that embraces every possible requirement for injection molding. A complete series of horizontal single unit machines of three basic sizes and several combinations of equipment provide injection capacities of from two to twelve ounces of plastic per cycle. Vertical machines with multiple injection units, in the creation of which H-P-M is world pioneer, provide for huge capacities, limited only by the ingenuity of the die maker and the practicability of the plastics themselves for extended applications.

The H-P-M INJECTION MOLDING PRESS with every element of its hydraulic operating equipment is entirely the product of The Hydraulic Press Manufacturing Company. Undivided responsibility with dependable, coordinated performance are thus assured each user.

Bring your plastic molding problems to H-P-M where a practical solution can be secured.

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District Sales Offices: New York, Detroit, Chicago; Representatives in Principal cities

Figure 5273

THE H-P-M MODEL 40-H-2
INJECTION MOLDING PRESS

CAPACITIES

The Model 40-H-2 is a complete self-contained injection molding press of the horizontal clamp type. Though the smallest machine of the complete H-P-M line, it is a most profitable volume producer of small plastic parts, capable of cycling very fast – providing large output with economical dies. A well balanced, completely equipped plastic plant should have several machines of this size.

Clamp pressure – 40 tons.

Maximum mold size – 11½" x 14".

Minimum shut height of mold – 6".

Maximum opening between platens, open position – 18".

Maximum stroke of mold carrier platen – 12".

Maximum weight of material injected, one cycle – 2 oz.

Pressure per square inch on material in injection chamber – 13,500 pounds.

Number of complete cycles per minute – 3 to 6.

Outstanding, Exclusive H-P-M Features

H-P-M DIRECT PRESSURE HYDRAULIC CLAMP – providing follow-up pressure under heavy load.

H-P-M VARIABLE CAPACITY RADIAL PUMP HYDRAULIC DRIVE – for maximum power economy and complete control.

H-P-M FLUID HEATING OF INJECTION CHAMBER – provides positive control over plastic temperatures.

THE HYDRAULIC PRESS MFG. CO., MOUNT GILEAD, OHIO, U. S. A.

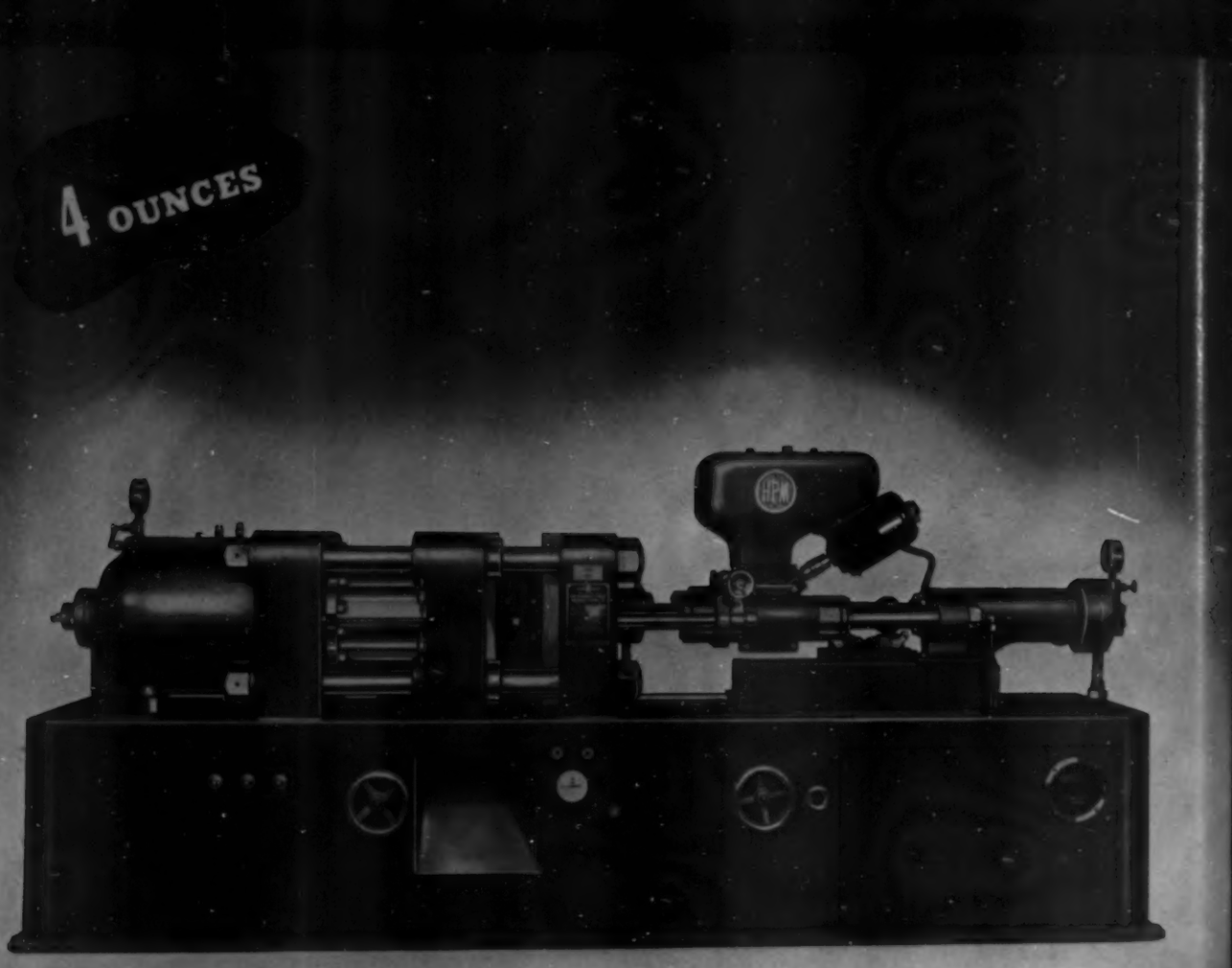

Figure 5333

THE H-P-M MODEL 100-H-4
INJECTION MOLDING PRESS

CAPACITIES

The Model 100-H-4 is the second size Injection Molding Press in the H-P-M line. Of intermediate capacity, it is equally suitable for long run production and small job lots because in favor of the latter molds can be changed quickly and no fine adjustments are necessary in changing from one job to another.

Clamp pressure – 100 tons.

Maximum mold size – 16⅛" x 24".

Minimum shut height of mold – 6".

Maximum opening between platens, open position – 18".

Maximum stroke of mold carrier platen – 12".

Maximum weight of material injected, one cycle – 4 oz.

Pressure per square inch on material in injection chamber – 20,000 pounds.

Number of complete cycles per minute – 3 to 6.

Outstanding, Exclusive H-P-M Features

H-P-M DIRECT PRESSURE HYDRAULIC CLAMP – provides follow-up pressure under heavy load.

H-P-M VARIABLE CAPACITY RADIAL PUMP HYDRAULIC DRIVE – for maximum power economy and complete control.

H-P-M FLUID HEATING OF INJECTION CHAMBER – provides positive control over plastic temperatures.

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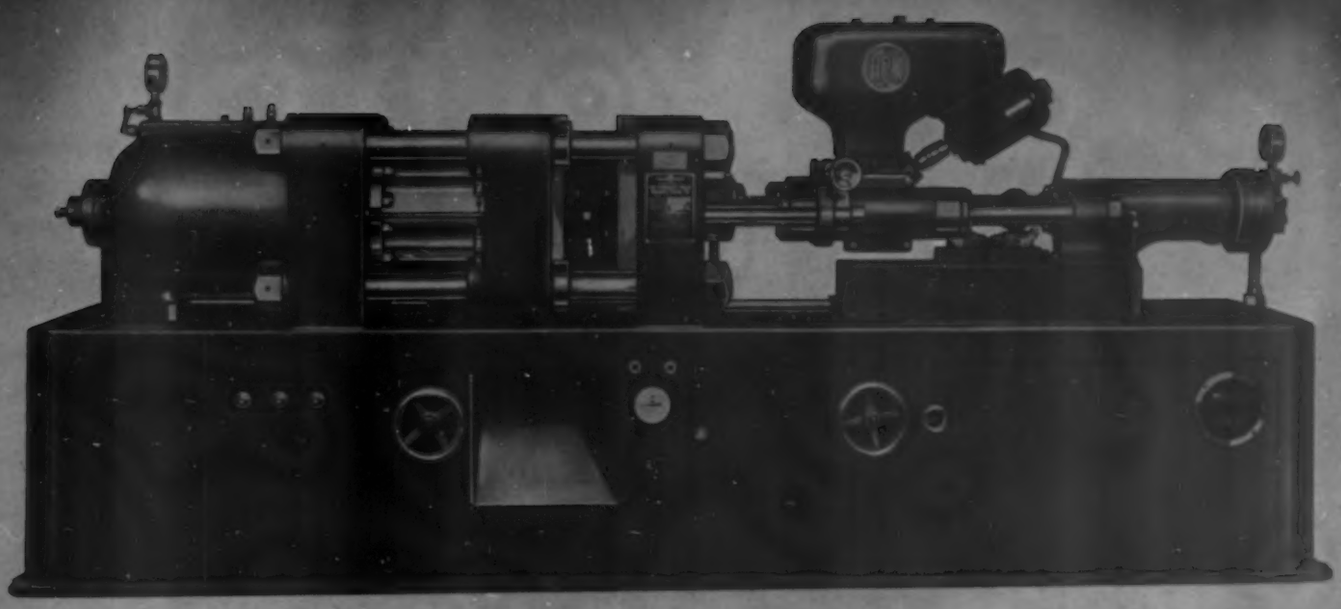

7 OR 9 OUNCES

Figure 5259

THE H-P-M MODEL 200-H-7 OR 9 INJECTION MOLDING PRESS

CAPACITIES

The Model 200-H-7 or 9 meets the modern demand for increased capacity in injection molding. It follows the latest design H-P-M has developed in the horizontal type with heavy clamp pressure. This size is definitely a large producer – capable of clamping and filling the largest molds it is practical to handle in a horizontal-type, single-unit machine.

Clamp Pressure – 200 tons.

Maximum mold size – 16½" x 24".

Minimum shut height of mold – 6".

Maximum opening between platens, open position – 18".

Maximum stroke of mold carrier platen – 12".

Maximum weight of material injected, one cycle – 200-H-7.....7 oz. 200-H-9.....9 oz.

Pressure per square inch on material in injection chamber – 20,000 pounds.

Number of complete cycles per minute – 3 to 6.

Outstanding, Exclusive H-P-M Features

H-P-M DIRECT PRESSURE HYDRAULIC CLAMP – provides follow-up pressure under heavy load.

H-P-M VARIABLE CAPACITY RADIAL PUMP HYDRAULIC DRIVE – for maximum power economy and complete control.

H-P-M FLUID HEATING OF INJECTION CHAMBER – provides positive control over plastic temperatures.

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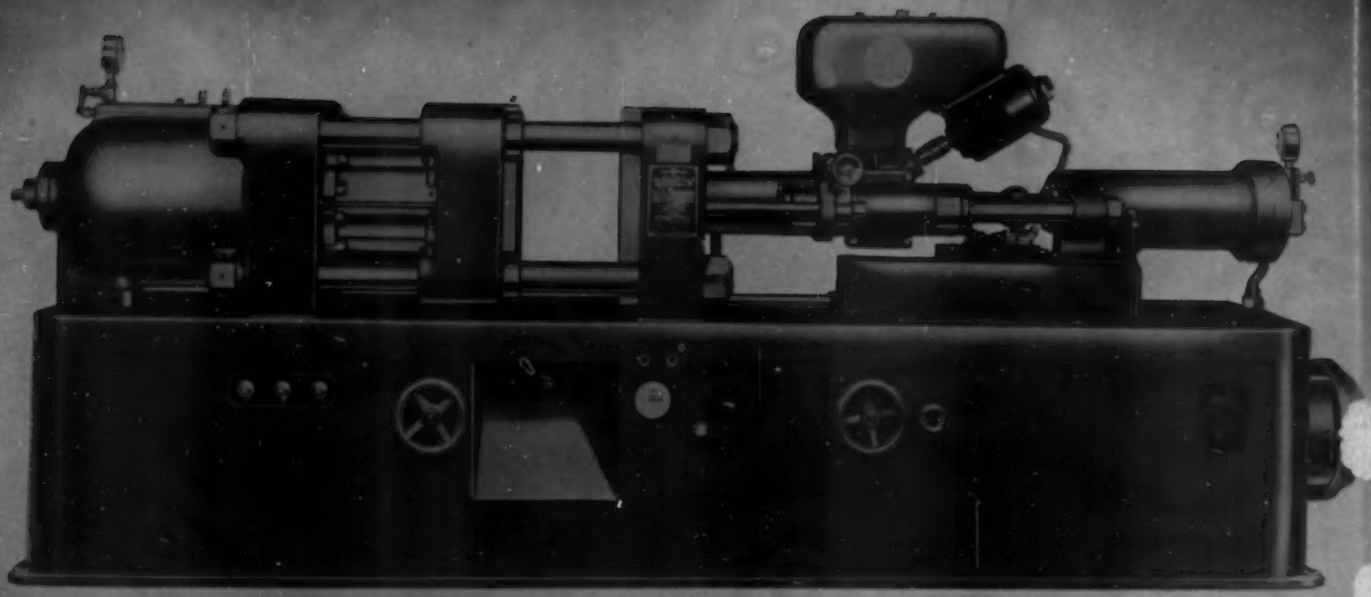

6 OR 9 OR 12 OUNCES

Figure 5332

THE H-P-M MODEL 200-HX-6 OR 9 OR 12

INJECTION MOLDING PRESS

CAPACITIES

The H-P-M Model 200-HX-6 or 9 or 12 follows the established design of the H-P-M Horizontal Clamp Type – but with pressure on material stepped up to 30,000 pounds at increased injection plunger speeds, thus injection capacity is not sacrificed for the higher pressure. The clamp unit duplicates that of the 200-H line; injection unit is especially built throughout for practical operation at increased pressure. Each unit is individually operated from separate H-P-M Radial Pump Power Units. Additional power capacity provides for full injection output at the increased injection pressure.

Clamp pressure – 200 tons.

Maximum mold size – 16½" x 24".

Minimum shut height of mold – 12".

Maximum opening between platens, open position – 18".

Maximum stroke of mold carrier platen – 12".

Maximum weight of material injected, one cycle –
200-HX-6..... 6 oz. 200-HX-9..... 9 oz.
200-HX-12.....12 oz.

Pressure per square inch on material in injection chamber – 30,000 pounds.

Number of complete cycles per minute – 3 to 6.

Outstanding, Exclusive H-P-M Features

H-P-M DIRECT PRESSURE HYDRAULIC CLAMP – provides follow-up pressure under heavy load.

H-P-M VARIABLE CAPACITY RADIAL PUMP HYDRAULIC DRIVE – for maximum power economy and complete control.

H-P-M FLUID HEATING OF INJECTION CHAMBER – provides positive control over plastic temperatures.

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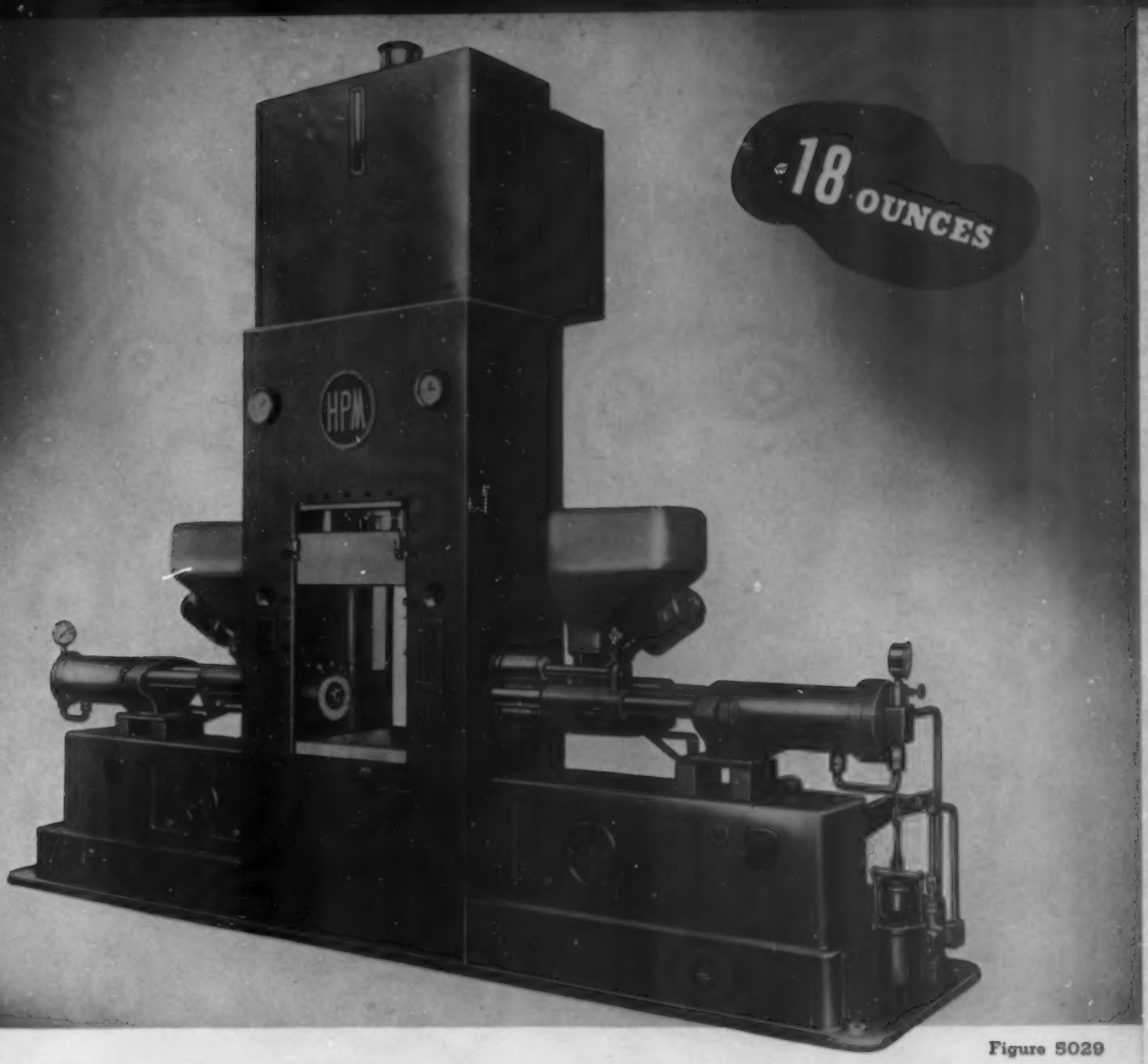

Figure 5029

THE H-P-M MODEL 250-V-DOUBLE 9
INJECTION MOLDING PRESS

CAPACITIES

The H-P-M Model 250-V-double 9 machine incorporates two complete injection units, one on each side of the vertical downward-acting clamp press, and hydraulically synchronized in their movement with those of the press. It has a capacity of 9 ounces per shot per unit – or a total of 18 ounces per cycle. The press as well as the two injection units are individually operated, each having its separate H-P-M Radial Pump Power Unit.

Clamp Pressure – 250 tons.

Maximum mold size – 24" x 24".

Minimum shut height of mold – 10".

Maximum opening between platens, open position – 25".

Maximum stroke of mold carrier platen – 15".

Maximum weight of material injected, one cycle – 18 oz.

Pressure per square inch on material in each injection chamber – 20,000 pounds.

Number of complete cycles per minute – 3 to 5.

Outstanding, Exclusive H-P-M Features

H-P-M DIRECT PRESSURE HYDRAULIC CLAMP – provides follow-up pressure under heavy load.

H-P-M VARIABLE CAPACITY RADIAL PUMP HYDRAULIC DRIVE – for maximum power economy and complete control.

H-P-M FLUID HEATING OF INJECTION CHAMBER – provides positive control over plastic temperatures.

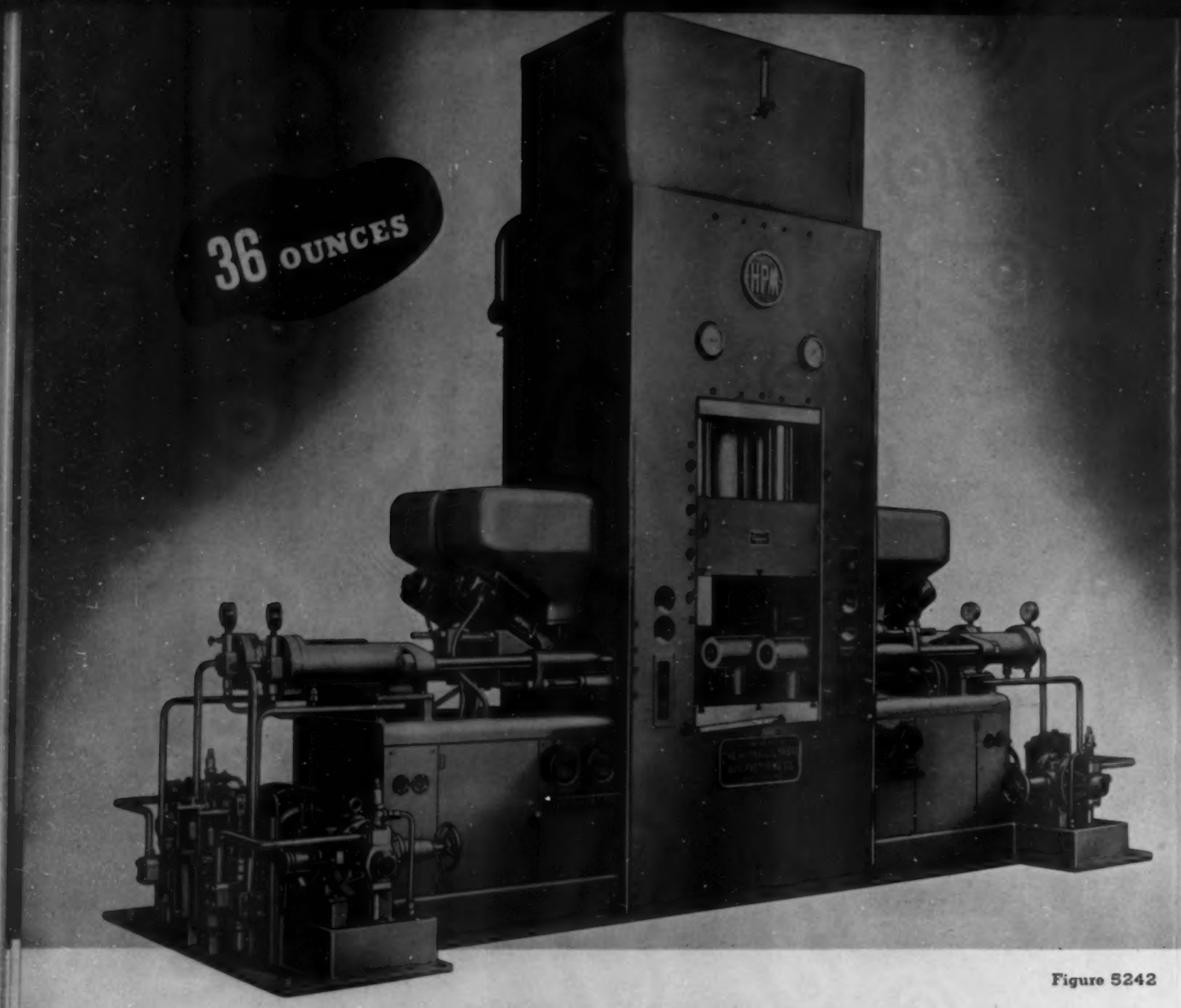

Figure 5242

THE H-P-M MODEL 500-V-QUADRUPLE 9 INJECTION MOLDING PRESS

CAPACITIES

The H-P-M Model 500-V-Quadruple 9 machine steps up plastic molding capacity to a total of 36 ounces per cycle. It consists of a vertical, downward-acting press in which the molds are clamped and four injection units, two on each side of the press. Each unit has its own individual power unit which is synchronized with the press and its operating equipment. The clamp press, like the Model 250-V, is operated by the patented H-P-M Fastraverse System which has been in use on H-P-M Fastraverse Presses for more than ten years in sizes from 50 to 5,000 tons pressure capacity. Such H-P-M presses, equipped with a battery of H-P-M injection units, afford almost unlimited future possibilities for huge capacities.

Clamp pressure – 500 tons.

Maximum mold size – 36" x 48".

Minimum shut height of mold – 16".

Maximum opening between platens, open position – 40".

Maximum stroke of mold carrier platen – 24".

Maximum weight of material injected, one cycle – 36 oz.

Pressure per square inch on material in each injection chamber – 20,000 pounds.

Number of complete cycles per minute – 3 to 4.

Outstanding, Exclusive H-P-M Features

H-P-M DIRECT PRESSURE HYDRAULIC CLAMP – provides follow-up pressure under heavy load.

H-P-M VARIABLE CAPACITY RADIAL PUMP HYDRAULIC DRIVE – for maximum power economy and complete control.

H-P-M FLUID HEATING OF INJECTION CHAMBER – provides positive control over plastic temperatures.

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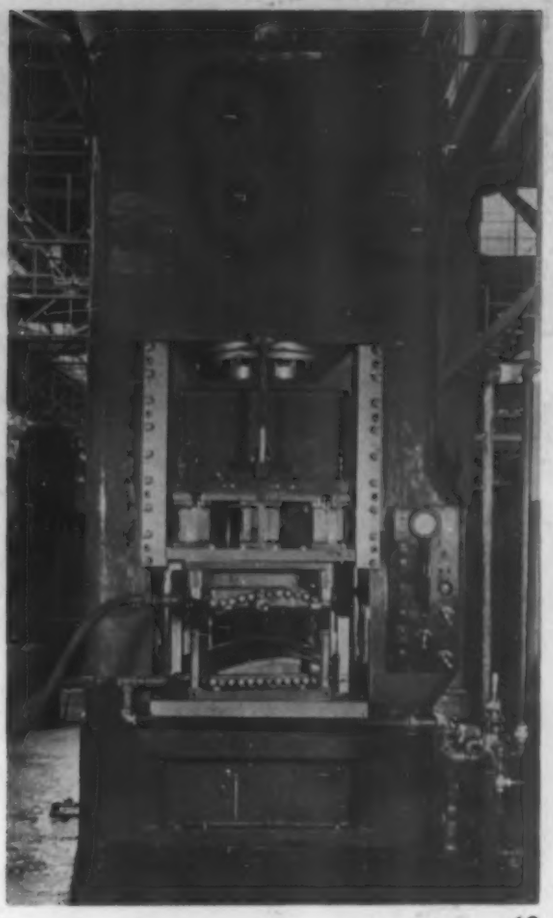
Fig. 11—Part of the battery of French Oil Mill molding presses at work in the Ford Motor Co. plant at Detroit. On the press at right (Fig. 12) may be seen the huge cast mold in which trunk compartment covers for Mercury cars are being experimentally molded



12

COMPRESSION PRESSES

(*Continued from page 304*) but also the pressure as well. In other words, it is possible for the operator to set, by means of a certain valve, the desired pressure which is generally anywhere from the maximum down to practically zero to suit the particular piece or part being molded. This is of considerable advantage when small molds are being run in a large press as it eliminates the excess pressure which is apt to damage the mold. Also when delicate inserts are used, too much pressure is apt to either break or move them out of position.

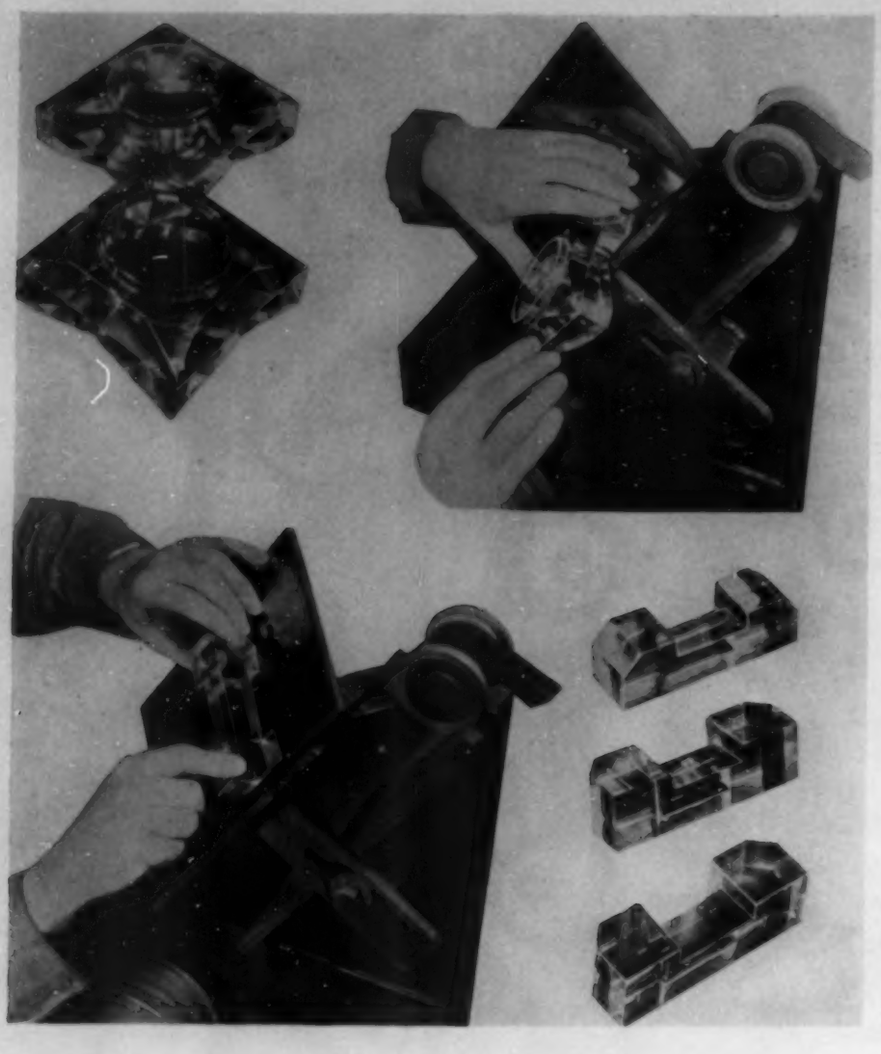
One of the most important developments of recent years is the time cycle control of the operation. This can be used on either the accumulator operation or the self-contained type of press. On the accumulator operated press, diaphragm type of valves is used having a large air diaphragm at the top and the time cycle control is essentially a synchronous motor with a cam which operates small air valves. When the press is loaded, the time cycle control is started and the press is closed and held to a definite period of time and then opened. It is also possible to gas the mold or, in other words, release the pressure temporarily and then automatically come on again. Where heating and cooling are required in the cycle, it is possible to operate the steam and cold water valves the same way and from the same timer. In the self-contained presses, the time cycle control is generally electric, that is, electrical solenoids are operated on the pressure valve although in some cases a similar type of synchronous motor with an air operated valve timer is used in conjunction with an air cylinder on the hydraulic control valves.

With this type of time cycle control, it is possible to duplicate the curing period exactly, eliminating all of the personal elements, insuring absolute uniformity of finished material, providing all of the other conditions are constant. With these time cycle controls it is possible to vary the cycle from one set of molds to another very easily.

This time cycle control has been used principally with the larger manufacturers but we predict that these will be introduced to a greater extent with the custom molders in order to avoid loss due to parts being over- or undercured, causing scrap.

General

With the wide range of sizes, designs, operation, and control, it is possible now to obtain a correct press for any particular type of compression molding. Developments are being made every day and the manufacturers of the hydraulic presses are anticipating the requirements of present-day custom molders.



Lucite pieces being sanded with Wetordry Tri-M-ite cloth using a jig to maintain original angle during the operation. Final polish is obtained by buffing

1

FINISHING METHODS AND EQUIPMENT

by J. DELMONTE*

ARTICLES PRODUCED FROM PLASTIC MATERIALS owe much of their popularity to the high quality of the finish appearing on their surfaces. So important an aspect of the plastics industry has this become, that custom molders, manufacturers of laminated plastics, and fabricators of cast plastic materials are establishing standard techniques and installing adequate facilities for the finishing of their products. Though the term, finishing, was interpreted in the early days of the plastics industry to mean only polishing, today it is inclusive of those operations which have to do with the handling of materials from the time they leave the molds and presses, until they are packed and ready for shipment. These operations may include sanding, filing, drilling, tapping, tumbling, cleaning, buffing, wiping-in lacquers, miscellaneous machining and engraving, polishing, gaging, cementing, and inspection.

* Instructor in Plastics, Armour Institute.

Why finishing operations

While plastic materials will reflect the finish of the mold surfaces or the platen between which they are pressed, further operations are necessary to increase the utility of the article and to augment the finish which is already present. To understand the nature of the finishing operations and why they are so important, it is necessary to examine certain features of molding, laminating, or casting methods employed.

Molding. While fundamentally the design of the molded article will determine where the mold will be divided, general observations may be made on the nature of mold parting lines as influenced by the design of the mold, the method of molding, and the number of cycles that have been completed. In conventional hot compression molding or cold molding, the materials are introduced into the mold cavity before the mold halves are clamped together. The excess molding materials

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ABOVE PHOTO SHOWS BATTERY OF ELEVEN GORTON MACHINES AT CHICAGO MOLDED PRODUCTS CORP.

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Photographs on left show part of this installation with close-ups of two precision molding jobs on regular production.

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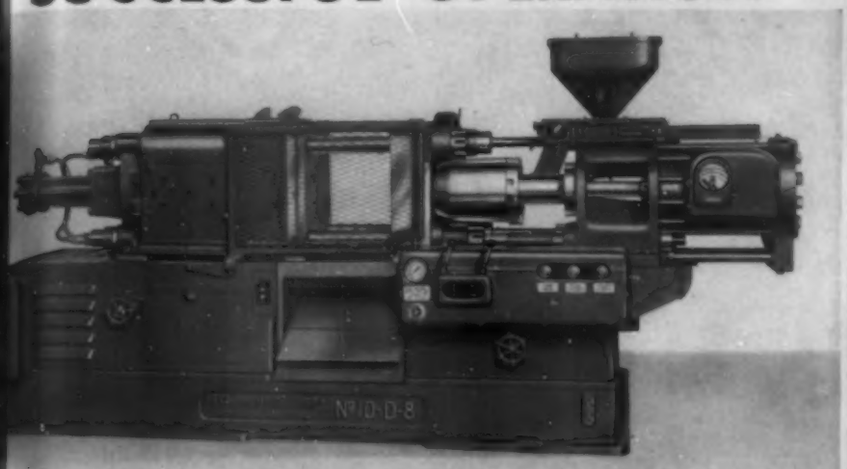

SPECIFICATIONS	10A-2 oz.	10A-4 oz.	10D-6 oz.	10D-8 oz.
Ounces molded per shot	2	4	6	8
Plasticizing capacity per hour	32 lbs.	36 lbs.	45 lbs.	56 lbs.
Pressure per square inch on material	20,000 lbs.	20,000 lbs.	20,000 lbs.	20,000 lbs.
Rate of injection, cubic inches per second	7.3"	7.3"	11.4"	11.4"
Size of die plates	19½" x 21"	19½" x 21"	21" x 25"	21" x 25"
Space between bars	12" x 12"	12" x 12"	11¾" x 14¾"	11¾" x 14¾"
Mold opens	8"	8"	8"	8"
Maximum die space	18"	18"	18"	18"
Minimum die space	7"	7"	7"	7"
Maximum casting area in mold	36 sq. in. @ 20,000 lbs. pressure per sq. in.	36 sq. in. @ 20,000 lbs. pressure per sq. in.	66 sq. in. @ 20,000 lbs. pressure per sq. in.	66 sq. in. @ 20,000 lbs. pressure per sq. in.
Capacity of feed hopper	40 lbs.	40 lbs.	50 lbs.	50 lbs.
Motor required	15 H.P.	15 H.P.	20 H.P.	20 H.P.

Machines available for Higher Pressures up to 40,000 lbs. per sq. in. on material. [No extra charge.]

TYPICAL PRECISION MOLDING OF OTHER CUSTOMERS
(Photographs on right)

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will appear along horizontal flash lines in flash molds or as vertical fins in positive mold designs. While the operator may knock off most of the flash or fin on the molded articles when removing the pieces from the cavities, that will not suffice. Further operations for obtaining a smooth even finish are necessary, particularly if a low production mold without a high polish is employed in molding.

Though flash lines are kept to a minimum in transfer and injection molding, where the molds are clamped together before the material is introduced, gates and sprues must be trimmed from the molded articles and the actual points of entry into the molded pieces finished to conform with the remainder of the articles. Further, as compression, transfer, and injection molds wear, flashes and fins increase in thickness, necessitating more careful and longer finishing operations.

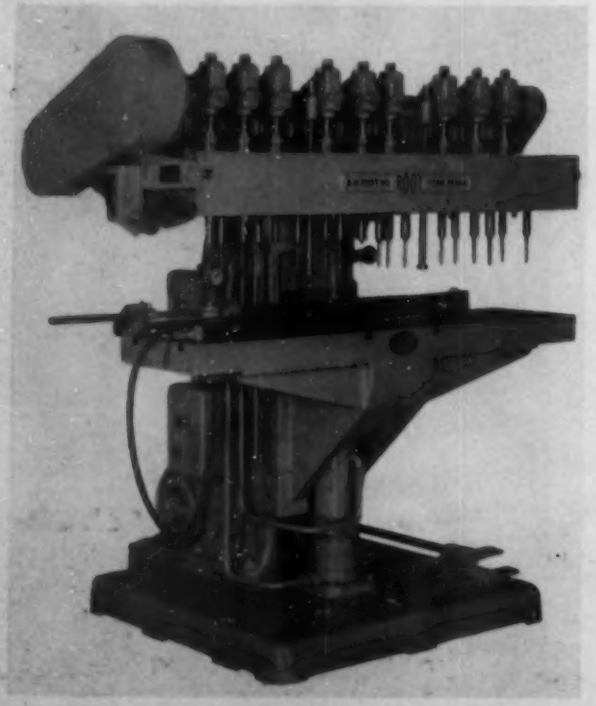
For the sake of illustration, a few examples of specific design features of molded articles which entail special finishing operations are cited below:

1. Wiping-in of enamel on engraved surfaces,
2. Location of mold parting line in middle of curved surface, requiring heavy and prolonged buffing,
3. Clearances between coring pins and force plugs in the mold,
4. Cementing molded plastic pieces together,
5. Drilling side and oblique holes, which may be impractical to mold into place,
6. Roll-leaf embossing and pressing overlays in place on the surface.

Laminating. Finishing operations for laminated phenolics or ureas while not carried out as extensively as for molded plastics, are nevertheless of a special nature. The surfaces of large, flat, laminated sheets mirror the finish of the platen which contact the bottom and top surfaces. While the usual finish is a glossy, smooth surface, matte finishes, wood-grain finishes, and tapestry designs are not uncommon in laminated plastics. After the sheets leave the press the edges must be trimmed and sawed off to size. Manufacturers of laminated plastics often engage in further finishing operations such as cutting the sheets into strips and perhaps drilling them; grinding tubes or rods down to accurate dimensions and cutting them off to given dimensions; and drilling and pressing in inserts. While many industrial consumers purchase their laminated stock in sheet, bar, or rod stock, there are certain economies to be gained by conducting finishing operations at the plant of the plastic laminator.

Casting. Cast articles of plastic materials and articles machined from cast rods, bars, tubes, or special shapes make extensive use of finishing operations. Removal of flash from the larger cast housings and removal of tool marks from smaller machined pieces constitute the prime reasons for further finishing. Tumbling, buffing, and polishing are a few of the many finishing operations employed to restore the natural luster to cast articles, which were impaired by machining. Developments in transparent and translucent cast plastics have necessitated particular pains in polishing as blemishes are readily seen.

Here is a multiple-spindle drilling machine made by B. M. Root Co., designed for rapid finishing of plastic parts



Finishing operations as affected by the plastic material

The identity of the plastic material will have a bearing upon the technique to be followed in the finishing. The glossy surfaces of phenolics and ureas are due to a thin, transparent layer of pure resin which separates itself from the reinforcing materials. The heat from a smoothly polished mold surface, or the heat from localized friction developed in tumbling or buffing will sweat out this layer. The proportion of the resin present, the dyes, and the fillers employed will also have an important bearing on the finish that can be developed As thermoplastic materials have a much lower heat distortion point than the thermosetting plastics, greater precautions will be required for the former in buffing and polishing. Certain plastic materials will take on a good polish with the minimum of difficulty. Among these are casein plastics, cast phenolics, and cellulose plastics.

Some of the synthetic resins are more brittle than others and require certain precautions in finishing, particularly rough finishing and machining operations. Urea plastics, for example, should not be coarse filed as small cracks may originate along the edges where tool marks appeared. In other operations, phenolic and acrylic plastics will tend to chip at the point where the drill enters the material, and hence may require countersinking. As the various finishing operations are discussed, differences as occasioned by the nature of the plastic material and its method of fabrication will be described more fully. It will be found that manufacturers of equipments for finishing plastics, base their recommendations upon the material to be handled, volume to be treated, type of finish desired. (*Please turn to next page*)

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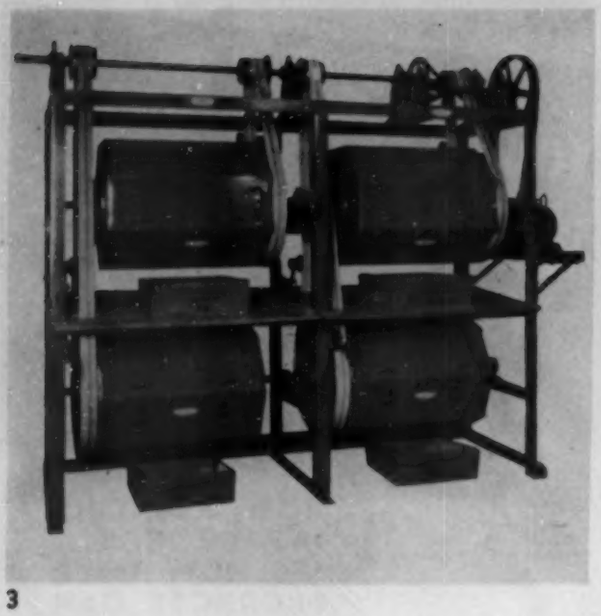

3

Four-unit Lupomatic tumbling barrel for dry polishing jewelry and other small plastic pieces. Shoe pegs and polishing compounds do the polishing as the eight-sided barrel revolves

Rough finishing operations

Included in rough finishing are filing, ashing, sanding, and rough tumbling, or any combination of these. Which methods are to be pursued are largely determined by the size of the piece to be handled and the complexity of the design. Small compression molded articles or parts machined from cast phenolics are often handled very economically and satisfactorily by tumbling methods. On the other hand, larger molded articles, molded parts with thin sections or heavy inserts which may be broken in tumbling, or molded pieces with inserts that are apt to become filled with abrasive during tumbling, are better handled by manual means on a sanding belt and buffing wheel.

Filing. Filing operations by hand are currently employed on molded parts for openings or corners where the flash lines are not easily reached by other methods. An example of such a piece is the removal of flash between the louvers of a molded radio housing. Among other examples employing hand filing operations are the sprue marks or projections appearing on injection molded articles. These may also be removed by a sanding belt, and smoothed down by tumbling or buffing.

Ashing. Rough cutting down of plastic materials, particularly large pieces is sometimes accomplished on an ashing wheel. A wet paste of ground pumice and water is fed from a container under the wheel by the operator, between the work and the buffing wheel. The grades of pumice which are employed by firms using these methods, are # 0 and # 0½. Muslin cloths are used in building up the buff. For a 12 in. to 14 in. diameter wheel, a speed of about 1200 r.p.m. is recommended. It is necessary to apply the pumice frequently to the wheel, as it does not adhere readily on the periphery of the wheel. Appreciably longer periods of time are required by this method than by many other roughing methods.

Sanding. In sanding equipment for finishing plastic materials, particularly noteworthy are the flexible abrasive belts. They are adapted to the rough finishing of medium and larger molded or cast articles. A typical example is the "Wetordry Tri-M-ite" cloth which employs a silicon carbide abrasive grain bonded by a synthetic resin. While abrasive belts with #24 to #600 mesh size abrasives are available, the grades ranging from #220 to #320 mesh have been found most useful for rough finishing plastics and the removal of sprue projections and heavy flash lines. The belt may be operated dry or in conjunction with a water spray nozzle, using belt speeds ranging from 2000 to 3000 ft. per minute on the surface. As the belt is flexible, it may be easily adapted to irregular surfaces. It is particularly effective for rapid cutting down, as may be occasioned by heavy flash lines or by cold molded pieces which are rather heavy in vertical dimensions. The cold molded pieces are not sanded until after they have been subjected to a baking operation.

Illustration of the use of flexible, waterproof abrasive belts is shown in the photograph on page 329, Fig 5. The flash line of an automobile steering wheel is pressed against an abrasive belt, and held in place by a special jig, which may be easily rotated to obtain uniform sanding. In Fig. 1, page 314, the rough finishing of a cast piece of acrylic plastic is shown. A rapid cutting down is obtained, and proper angles maintained by a special jig and table which may be set at any angle with respect to the abrasive belt. A buffing operation follows this procedure to develop high luster.

Among other sanding operations of note are those employing small abrasive papers for hand application in difficult corners of molded parts and small abrasive wheels driven by flexible shafts. The abrasive wheels are readily controlled in their movement by the operator and often form a valuable addition to the finishing department for plastics.

Rough tumbling. Rough tumbling operations are sometimes referred to as ashing operations and are well suited to removal of flash and fins from large quantities of small molded articles, as well as cut down tool marks on machined cast phenolics, casein or cellulose plastics. For the molded urea or phenolic plastics, barrel speeds of 20 to 40 r.p.m. are required, though for delicate edges where chipping may occur the speed is kept under 30 r.p.m. When the molded parts are to be de-finned small wooden pegs or burnishing balls are mixed with the parts and the tumbling proceeds 1 to 10 minutes. Removing flash from cellulose plastics requires a longer period of time, 3 to 6 hrs., using wooden pegs and some oils. Very heavy flashes on molded pieces caused by worn molds are better removed by filing or sanding.

When machined parts from casein, cellulose plastics, or cast phenolic stock are to be ashed by tumbling, dry tumbling has proved to be the most effective. An abra-

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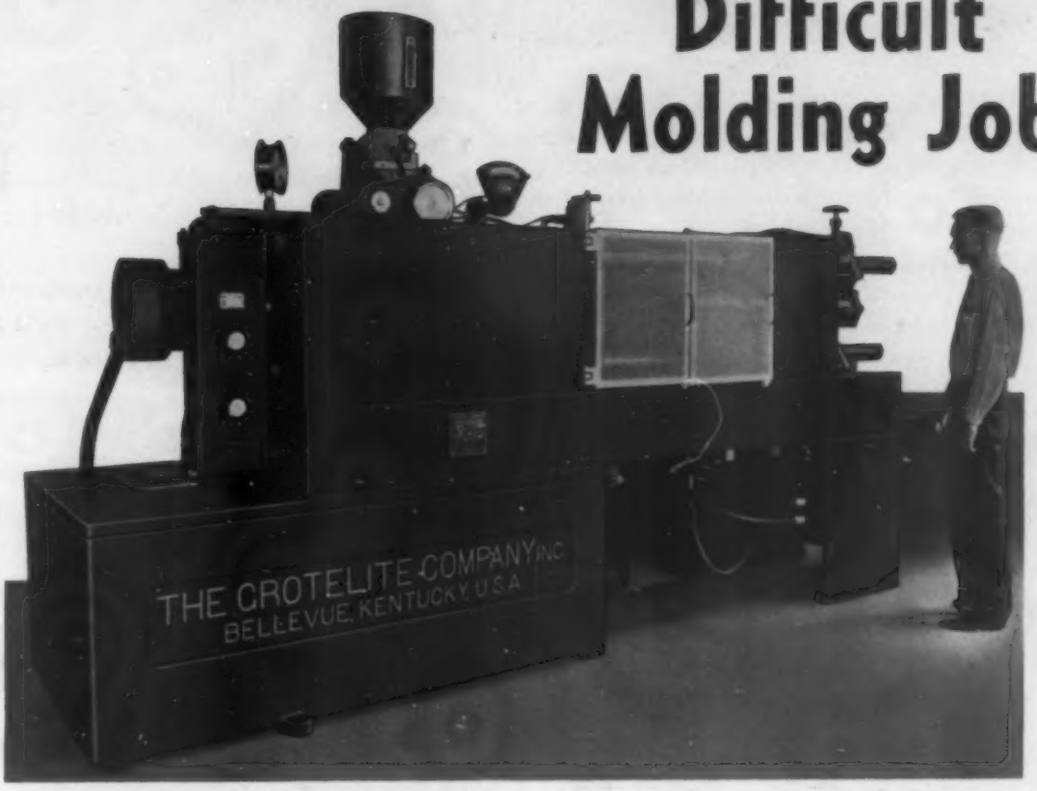

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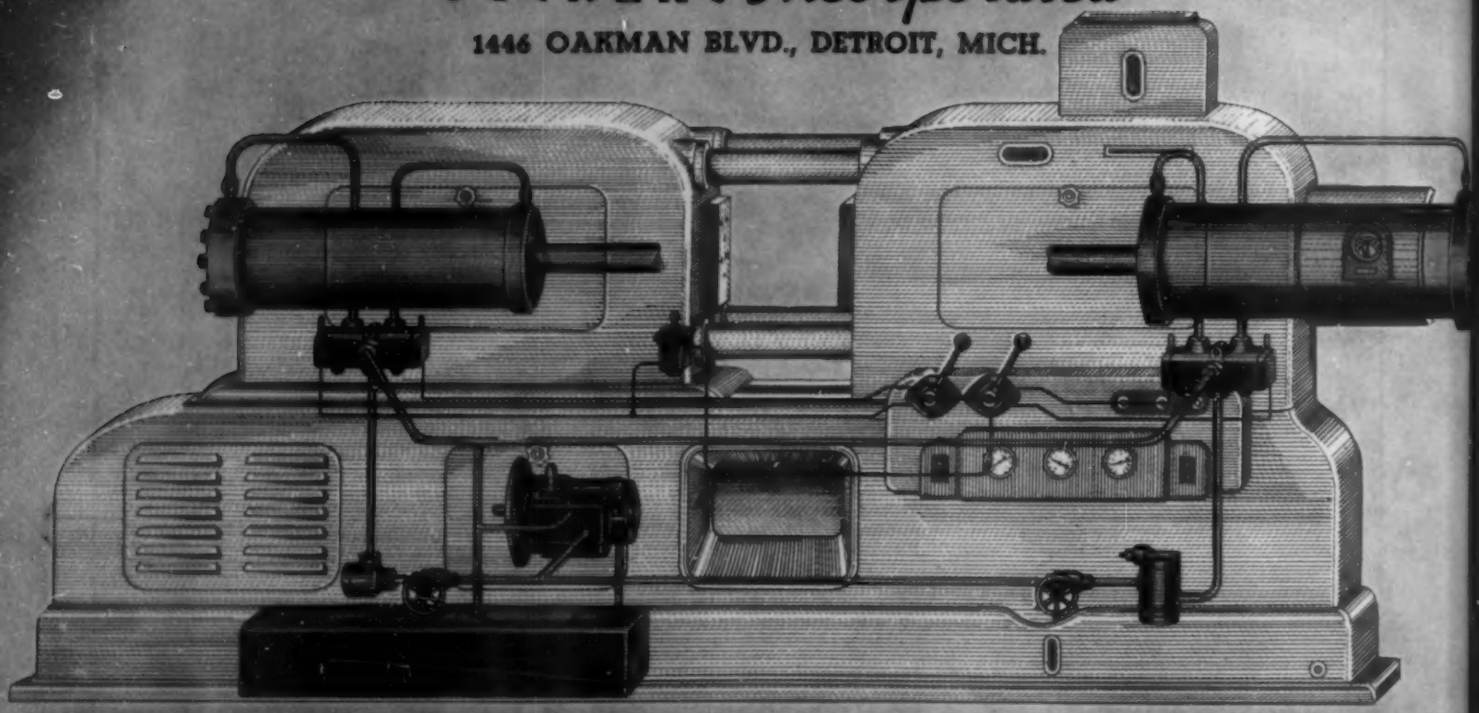

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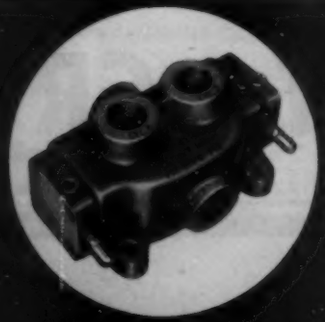

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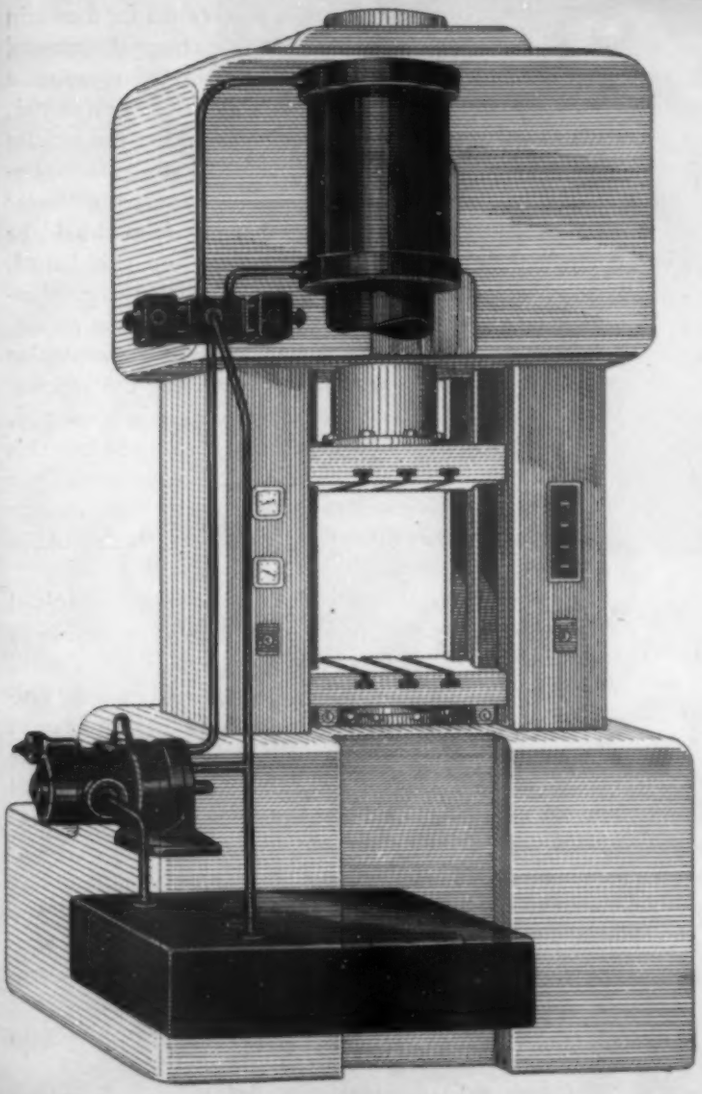

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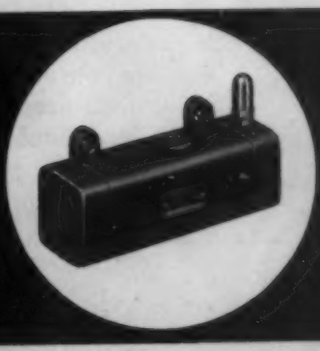

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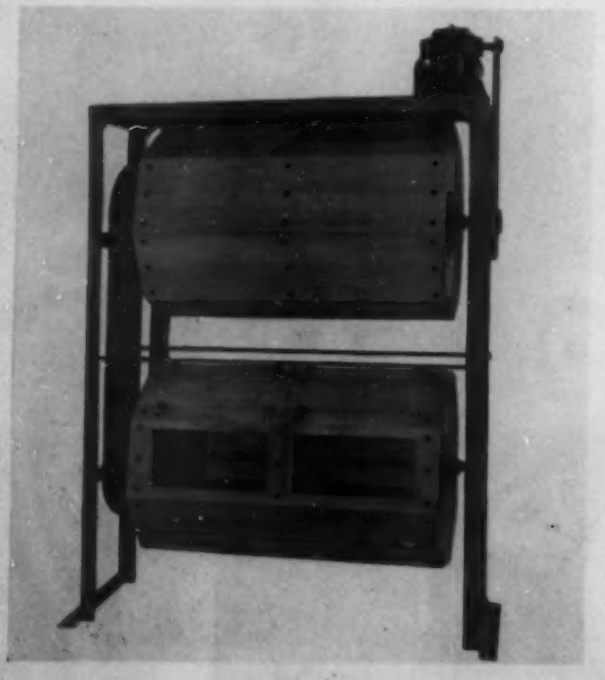
sive compound such as fine ground pumice, scrap plastic material, and wooden pegs or sawdust are added to the parts and the tumbling proceeds for 6 to 8 hrs. at a speed of about 30 r.p.m. until the articles are smooth. Replenish the abrasive compound when the cutting action slows down. At the end of the ashing operation the articles may be screened from other ingredients in the barrel. If a wet tumbling process is employed, washing and cleaning operations would be necessary. After this preliminary ashing operation, the machined parts are ready for further tumbling operations to develop various degrees of smoothness and gloss, as outlined in the following paragraphs. Tumbling operations insure uniformity of finish and the same degree of stock removal on all articles.

Polishing operations

In the polishing operations the final finish may be developed on the surface of the plastic material by several methods. As in the case of rough finishing the decision rests upon the size and complexity of the design of the piece. When the parts are of a design that will permit tumble finishing, this procedure is followed to reap the advantages of economical and uniform finishing. Otherwise, hand operations upon the buffing wheel may be used to develop a satisfactory finish, particularly upon larger pieces. Polishing operations take place after the molded pieces have been drilled or tapped, providing these last operations are necessary. Machined pieces from cast, extruded, or laminated stock may be polished directly after rough finishing. Polishing requires a longer period of time than rough finishing and may sometimes be divided into two or more stages.

Tumbling barrels may be set up in single or multiple units as production demands in individual plants. This twin-barrel unit, with motor drive attached, is made by Rudolph R. Siebert Company

4



Polishing small machined pieces by tumbling. There are many types of articles machined from sheet, bar, tube, or rod stock, such as buttons, bracelets, cutlery handles, jewelry, handles, knobs, ash trays, buckles, and many other small miscellaneous parts. The polishing of these articles may require another 10 to 16 hrs. in addition to the time already spent in the rough tumbling barrel. The actual time of polishing depends upon the type of finish desired, that is to say, whether low, medium, or high gloss is to be developed. The finishing of machined pieces is usually divided into two or three stages. The articles are transferred from one barrel to another upon completing each stage. In the first stage wooden pegs and the articles fill the barrel about one-half full and tripoli powder, sawdust, and oleic acid are added (recommended materials for cast phenolic pieces). The barrels are rotated without the benefit of operators for a certain period of time. The articles are then removed, screened from the pegs and abrasive, and transferred to another barrel. In the second barrel a finer abrasive, is employed, such as a precipitated chalk mixture. After the articles have been polished in this manner for a length of time depending on the degree of finish wanted, a very high luster may be attained by a wax polish. Articles should be carefully cleaned before introduction into this barrel, such as by tumbling for a few minutes with a large quantity of sawdust and oil. In obtaining the wax polish, beeswax and carnauba wax are dissolved in turpentine and poured over the wooden pegs covering the articles. The articles are tumbled until the final gloss is developed. Sometimes one of the stages may be eliminated but this may necessitate a longer tumbling period in one of the other stages. Barrels should be rotated continuously and allowed to develop the frictional heat which will aid the polishing operation.

Polishing small molded articles by tumbling. Molded articles do not require as long a polishing operation as machined pieces inasmuch as they come from a mold usually with a good surface. When the surfaces are uniformly smooth a wax polish employing a small amount of compound may be applied for 1 to 2 hrs. in the tumbling barrel for phenolic and urea articles. If a dull molded surface is to be polished, 6 to 8 hrs. may be required with a fine abrasive composition. Cellulose acetate articles as may be produced by injection methods may have the sprue filed or sanded off, and then introduced into the tumbling barrel. Usually 4 to 10 hrs. are required for finishing these molded articles, and in one operation, as compared to the 2 or 3 hrs. required for machined pieces. For the highest gloss finish, a wax polish in the tumbling barrel should prove satisfactory.

Polishing articles by buffing methods. Molded articles which are either too large or too delicate to be handled in the tumbling barrel, larger machined pieces, sheets, bars, etc., are often polished by buffing methods. Polishing operations of this nature may be divided into two stages depending upon the condition of the surfaces of the article to be polished. Assuming that coarse tool marks and scratches have been removed by rough finishing methods, fine scratches and fine tool marks may be

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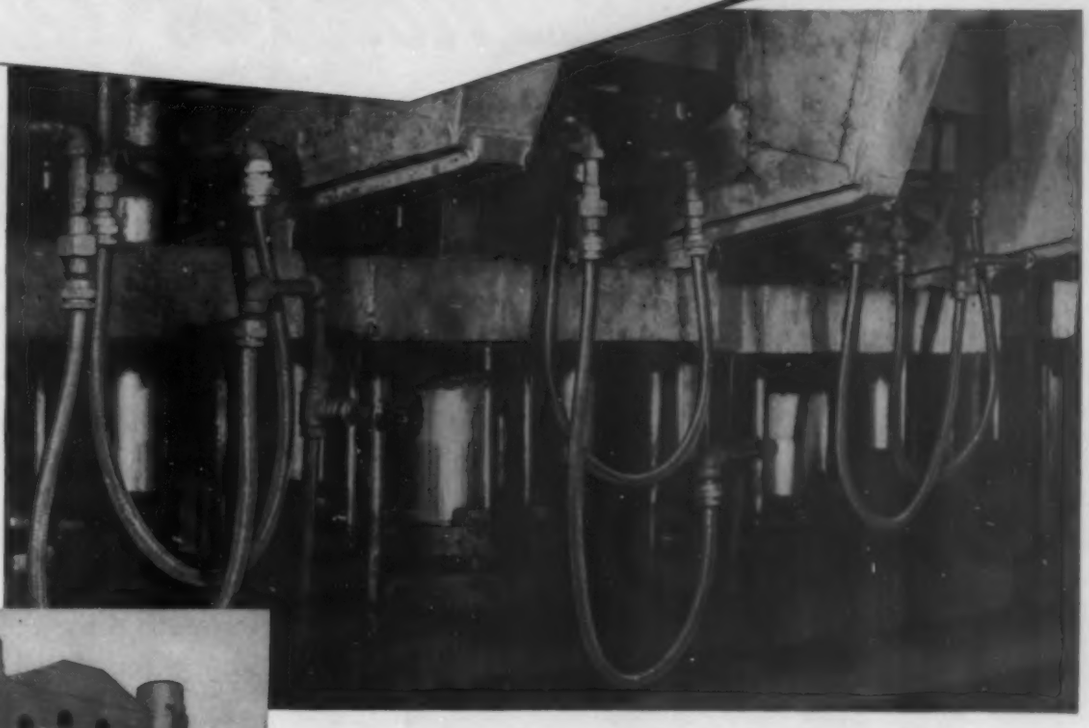

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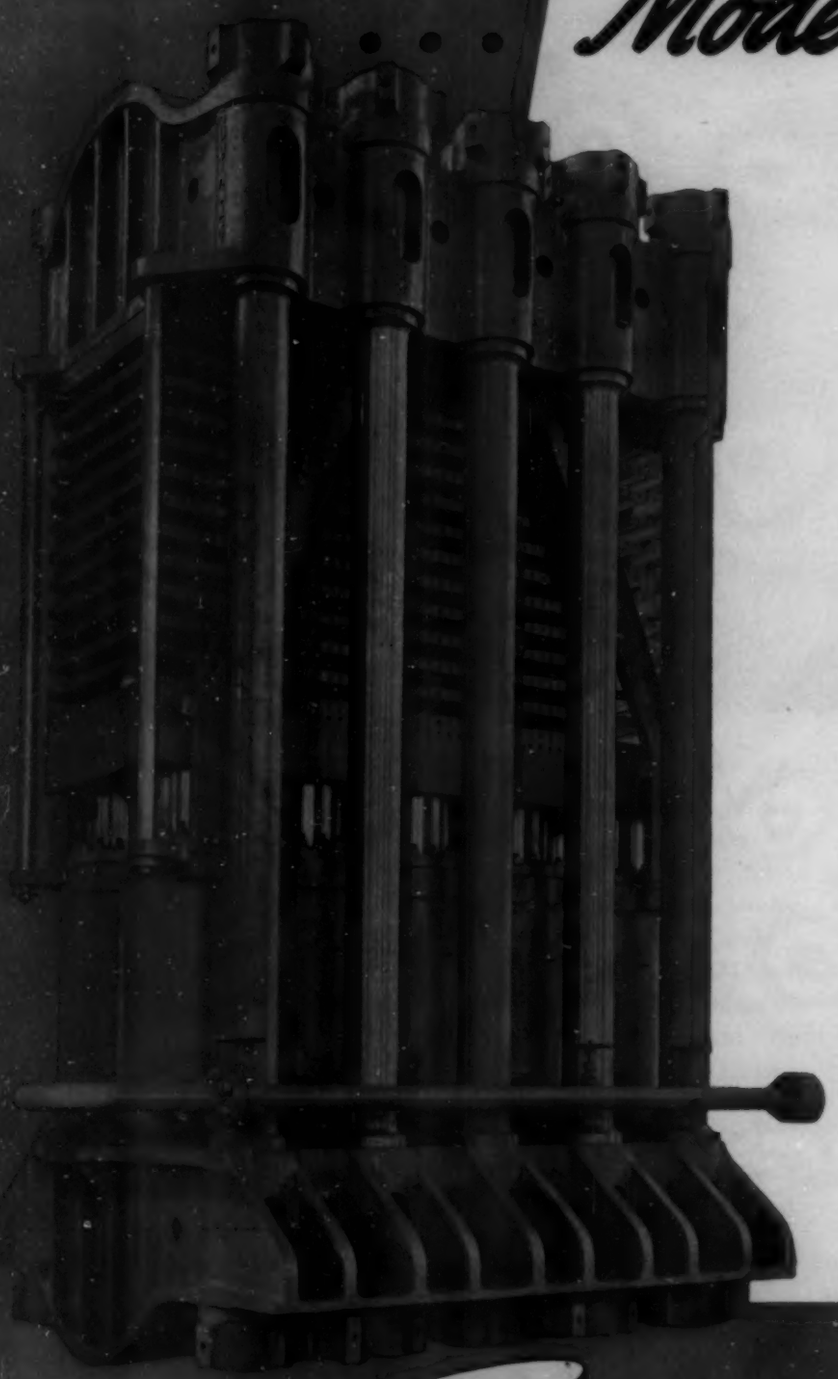

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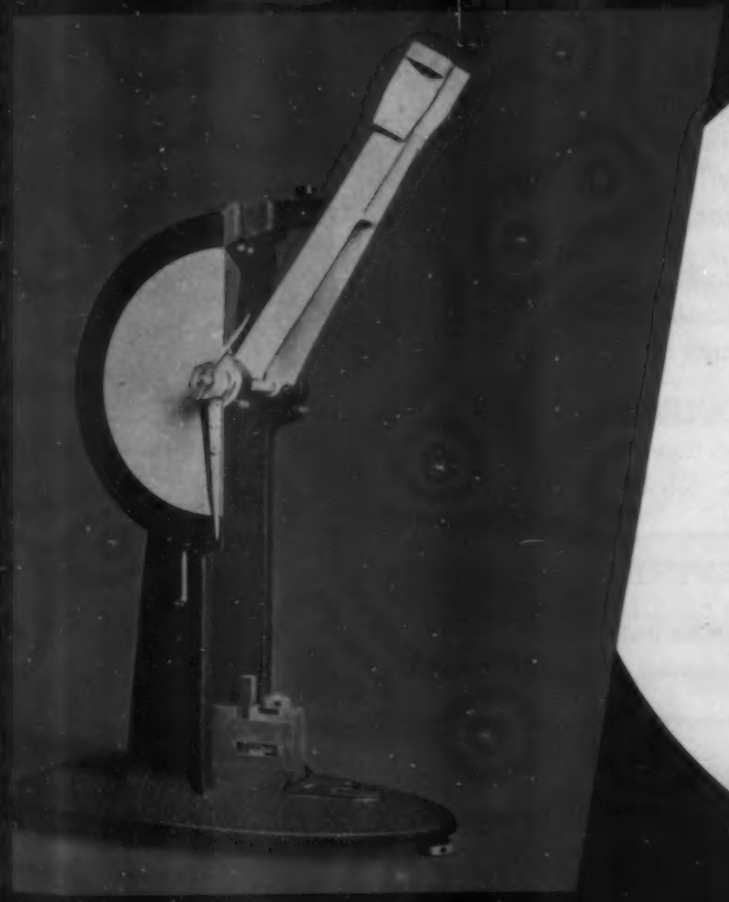
Southwark

Southwark Tilting Head Molding Press (upper left). Short stroke and accessible dies make this press fast and economical.

An Impact Machine for molded materials (lower left) which offers unexcelled accuracy and facility of operation.

Southwark Semi-Automatic Molding Press (below) completely self-contained and equipped with strippers.



HYDRAULIC *Presses*

The NOVEMBER Issue of

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removed by buffing on a muslin wheel. A tripoli composition applied to the buffing wheel will give general all around good results on plastics. A soft, well ventilated buffing wheel is preferred particularly in buffing thermoplastic materials, as the article must be kept moving and cool enough during operation to avoid heat marks or undulations on the surface as would be caused by the buffing wheel. Softer buffing wheels for polishing plastics are developed through an appropriate use of spacers between individual buffs and through a loose stitching of the buffs. Wheels built up in this manner will not burn the work as readily because of greater ventilation between the buffs, and will yield more easily to generously curved surfaces. For a more rapid cutting down action, as on the edges of sheet stock, frequent applications of a coarse buffing composition to a tightly sewn wheel will give good results. A 12 in. diameter wheel, 4 to 5 in. wide, should be rotated about 2500 r.p.m. for thermosetting plastics, and about 1500 r.p.m. for thermoplastic materials, though a certain amount of experimenting is necessary for determining optimum speeds for different compositions and different wheel constructions.

The final polishing operation on the buffing wheel is usually referred to as a coloring operation, whereby the article is given a bright luster. There are several ways in which this operation may be conducted satisfactorily. Lustering compounds with a very fine abrasive will give good results, the amount of abrasive applied to the wheel being in smaller proportions and at less frequent intervals than in buffing. Lustering compounds should not be used for cutting down, as the time involved would incur too long an operation. Buffs built up from canton flannel are often employed in coloring plastics, and are operated at slightly higher speeds than in buffing. When large flat areas or sheets are involved, soapy water solutions with flannel buffs may be used for cleaning. Flannel buffs without any composition are also employed for a final wiping action on the article.

While machined articles or parts which come from unpolished molds may require the full complement of ashing, buffing, and coloring, some molded articles having an almost acceptable finish to begin with may require not more than one operation on the buffing wheel, usually in the nature of a coloring or wiping operation. This is often necessary even if the mold is polished, for the articles may have been handled after coming from the mold in drilling or tapping, hand filing or sanding of flash lines, and hence may pick up dirt and smudges.

Special polishing methods for thermoplastic materials. While less frequently employed than tumbling or buffing methods, dipping procedures have nevertheless proved satisfactory for some types of articles derivable from casein or cellulose plastics. This technique is usually suited to a large number of small articles though reasonable precautions must be observed to select a not too active solvent, in removing articles from the solvent, and in the method of removing volatile constituents. Solvents will tend to level out the microscopic ridges formed by very fine abrasives on the articles. Another specialized polishing technique, adaptable to dull or matte surfaces of sheets of thermoplastic materials, is to place them between highly polished platens under heat and pressure. Under these conditions a thin resin surface film will form giving the material a glossy finish.

5

Sanding automobile steering wheels with flexible abrasive belt made by Minnesota Mining and Mfg. Co. Arrow points to water inlet for the spray nozzle which cools the plastic material during the process

Recent trends in tumbling and buffing equipments

The tumbling barrels designed for finishing of plastics have undergone an extensive development to their present high state of efficiency. Varying 24 to 30 in. in diameter, and 20 to 50 in. long, they have a hexagonal or octagonal shape and are mounted so as to rotate about a horizontal axis. For abrasive or rough tumbling, an unlined steel barrel is often used, though in the more conventional type, maple, birch, and cypress liners are employed. The present tendency has been toward mounting the barrels one above the other to conserve floor space and handling, such as in Fig. 3, page 320 and Fig. 4, page 324. Space under the barrel permits removal and screening of the pieces. Recently developed tumbling barrels also reflect new trends in machine drives, with individual motor units mounted on the base of each machine.

While many of the developments in buff construction, buffing compositions, and buffing lathes are occasioned by the metal working industry, there are singular requirements on the part of the plastics industry. The utility of softer, well-ventilated buffs and special compositions has already been brought out in discussing buffing of plastic parts. As for design trends in polishing lathes, double-spindle machines, increased accessibility through longer overhang, and variable speed drives are most noteworthy. Installations of polishing and buffing

equipments are accompanied by adequate dust collectors and conduit to keep the surrounding atmosphere as clean and fresh as possible.

Drilling and tapping

Drilling and tapping operations are often conducted upon molded, laminated, and cast plastic parts. These operations are performed either after the article is removed from the mold or between rough finishing and final polishing. Generally, side holes are drilled and counterbored, cored holes tapped, or threaded inserts cleaned of molding compound by re-trapping. There are types of holes such as long thin or oblique holes for oil passage to motor bearings in molded plastic motor housings, which would be difficult to reproduce in molding, though are readily drilled into position. Another classic example is a radio housing, which to reproduce horizontally displaced holes would require a split mold, an expensive investment for units of that size. Radio cabinets often require drilling and counterboring operations on the sides. To expedite operations multi-spindle machines are available for drilling the articles. Often as many as 9 or 10 holes are drilled simultaneously with special jigs locating the work with respect to the various drilling heads. (Illustrated on page 318.)

The multi-spindle drilling machines is an important factor in the finishing of the materials, providing a ready means of reproducing certain design features which are not economically accomplished in other ways. Special drills are also important as, unlike metals, drilled holes in plastics tend to be smaller than the outside diameter of the drill. Drills and taps for plastics are ground oversize, and provisions made for greater chip clearance and a smaller amount of land, as well as greater leads on the drill. Nevertheless, taps are replaced at frequent intervals as they tend to overheat due to the low thermal conductivity of the plastic material, drawing the temper of the steel. The problem is less severe when the taps are used for brass inserts in the molded plastic, which may be for either the shaping of the threads or the cleaning of threads that had already been cut.

Miscellaneous machining operations on molded parts

There are certain miscellaneous machining operations other than drilling or tapping performed on molded plastic members, which serve to augment the utility of the article Through the use of appropriate chucking devices, parts may be turned down on the lathe to tolerances much closer than can be held in molding. This procedure is often carried out at the plant of the manufacturer rather than the custom molder, inasmuch as gages can be used to check assembled parts. Accurate tolerances are also obtained on laminated phenolics through the aid of grinding operations.

Engraving on molded and laminated plastic materials is sometimes accomplished through the use of pantograph machines. There are several types of jobs which require these individual finishing operations rather than reproduction on the molds. For example, personal articles of molded plastics are sometimes engraved with the name of the owner, a feature often proving to be a strong selling point for the article. Further, the surfaces may require a narrow slot machined in place for insertion of certain metal overlays. Insertion and pressing in of the overlays are regarded as part of the finishing procedure.

Wiping-in enamels and cementing

There is an increasing use of wiped-in enamels and lacquers on the surfaces of plastic parts and the cementing of pieces from different molds together. Both of these operations are properly included in the category of finishing operations, as they serve to prepare the article for industrial consumption. Designs and lettering are either molded or engraved in position and the enamel or lacquer applied either by spraying or brushing. The lettering or design is usually sunk beneath the surface of the body some .008 in. to .010 in., permitting the removal of excess lacquer or enamel material by wiping with a clean rag.

Cementing entails the uniting of two or more plastic members or one or more non-metallic members to a plastic piece, through the medium of a cement comprised essentially of a solvent for the plastic. There are numerous examples where this technique has brought about some decorative appeal in the design, by combining two types of plastic materials. In other instances, because of limited space, cementing of parts together serves to eliminate bulky attachment pieces, though unless there is a positive solvent action as in the case of some of the thermoplastic materials, the bond may tend to be more mechanically weak than the rest of the body. After the cements have had enough time to set, it may be necessary to polish the articles on a buffing wheel in order to remove excess cement.

Gaging and inspection

Gaging and inspecting of plastic parts bring to a conclusion the finishing of plastic parts. Accuracy of measurement is particularly necessary for molded parts which depend upon close tolerances for assembling to other pieces. While the usual depth, go and no-go gages are employed, it is often necessary to develop special gages for individual molded parts. Special gages may be in the nature of contour gages, gages for inspecting distances between cored holes, radius gages, etc., all of which permit the stamp of approval on special molded parts. Whether accurate gaging for dimensions is necessary or otherwise, final inspection of the quality of the article and the workmanship is imperative. Blemishes or defects as may arise from the molding material, mold, or finishing procedures, cause the rejection of many pieces. A knowledge of the nature of these defects and blemishes is obtained only through experience of what can occur in materials preparation and molding. There is no doubt but that a rigid inspection keeps satisfied customers, though too many rejects reduce the profit. However, custom molders have found that careful finishing procedures for their plastic parts greatly reduce the number of rejects in the final inspection.

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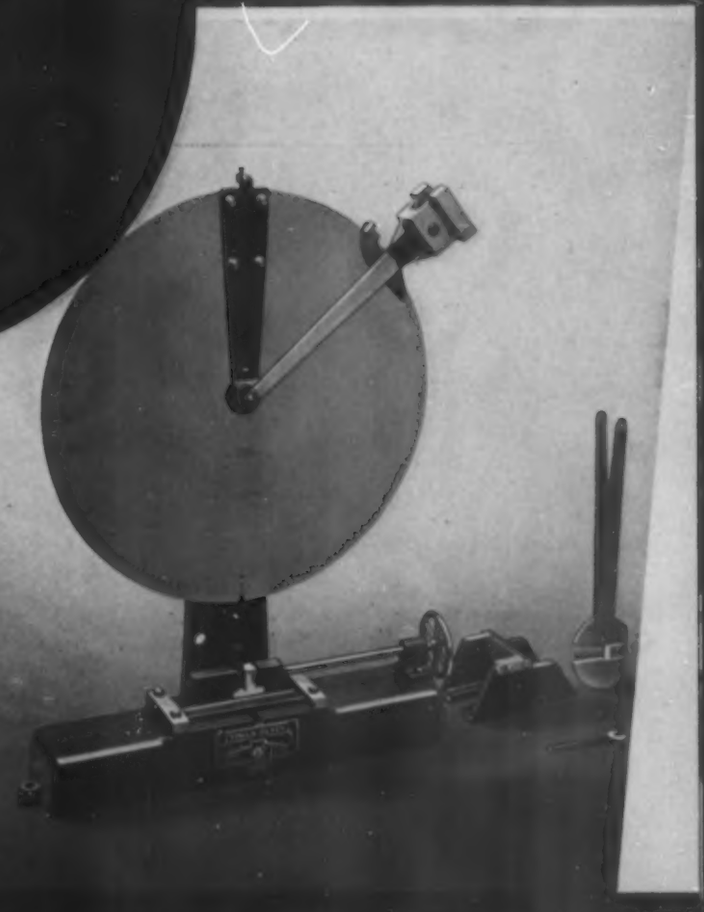

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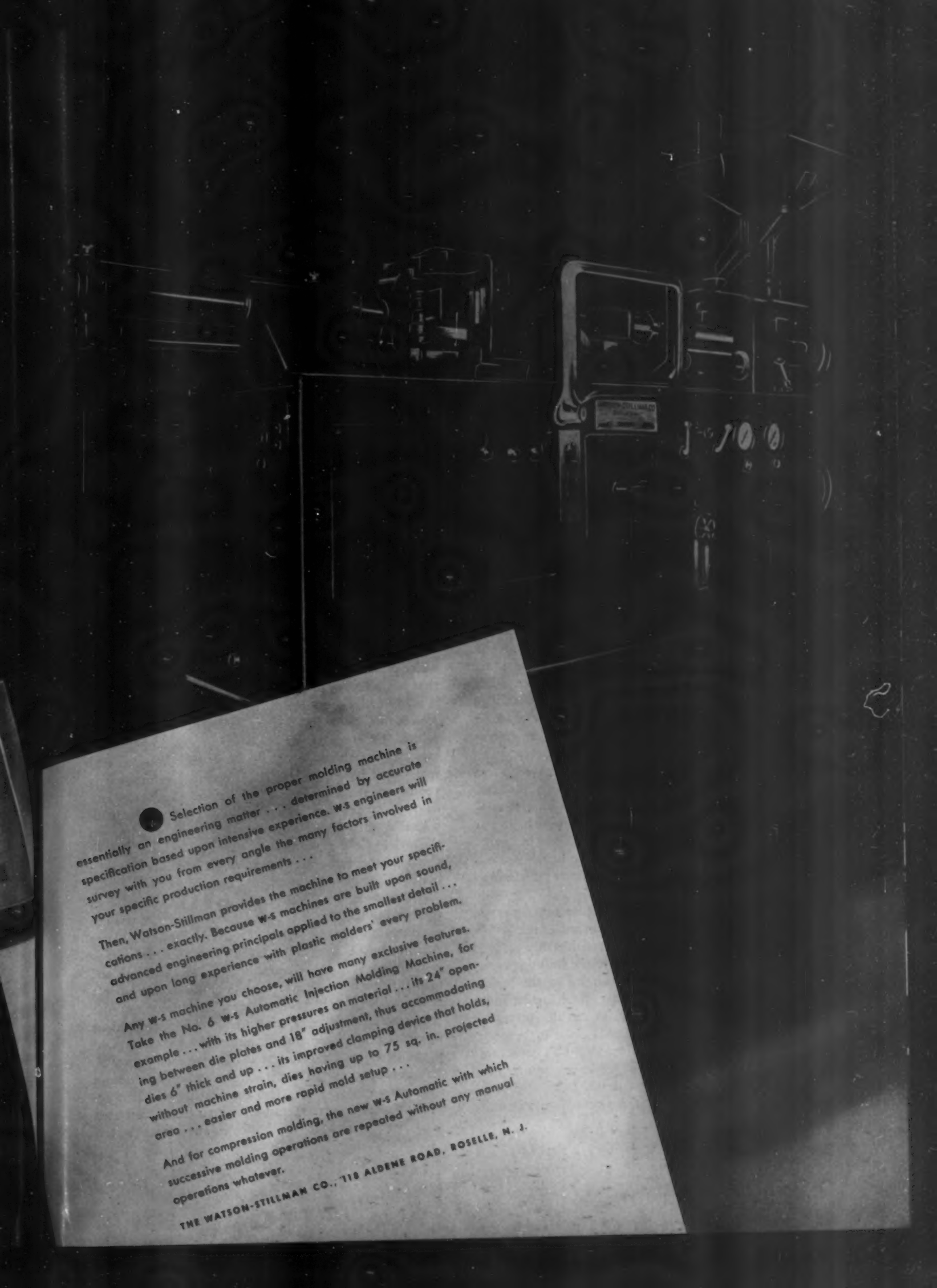

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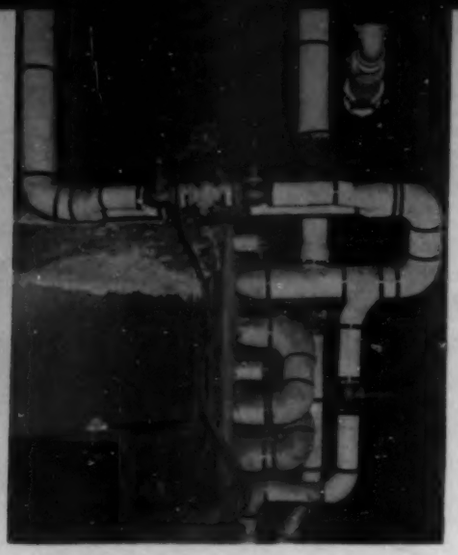

One of four long banks of molding presses at General Electric Co. (above left) heated by 370 deg. F. high pressure hot water from insulated overhead mains. Heater coils, on a treater oven at Synthane Corp. (right), with automatic control of high pressure hot water. (All photos by courtesy of J. O. Ross Engineering Corp.)

HEAT FOR MOLDING

by A. W. DE REVERE*

WHILE GAS AND ELECTRICITY ARE OCCASIONally used for the heating of platens or molds to the proper temperature for the molding of plastics and rubber, the heating medium in most general use has been steam. However, recently there has been introduced in several plants in this country a newer method—that of using "superheated" or high-pressure hot water which offers many advantages and economies in a molding plant.

To get a clear picture of the difference in use of steam and high-pressure hot water, let us first view the generation of heat in the boiler.

Any standard boiler may be used for either system and it may be fired by coal, oil or gas in the usual manner. An operating pressure is set to obtain the highest temperature required in the process heaters, which, if 350 deg. F. is desired, would be 120 lbs. per sq. in. gage. Water is fed to the boiler and heated up to the boiling point which is 350 deg. F. at the pressure of 120 lbs. per sq. in.

If steam is to be used as the heating medium for process work additional heat must be furnished in the boiler to vaporize the water in an amount considerably greater than required to heat the water up to the boiling point. For instance, assuming that water is fed to the boiler from a hot-well condition of 180 deg. F. at atmospheric pressure and raised to 350 deg. F. at 120 lbs. pressure, it would require 174 British Thermal Units of heat for each pound of water. If then 870 B.T.U.'s more are added to each pound of water it would be vaporized to dry saturated steam at 120 lbs. pressure and still at a temperature of 350 deg. F. It is this heat of vaporization or "latent" heat that is given up when steam condenses in the pipe lines and heating apparatus.

The steam will propel itself through the piping to heat users but at the expense of part of its heat and pressure; then in the heating apparatus it condenses still under pressure and in doing so gives up the latent heat that has been put into it in the boiler. The condensate is water under pressure which must be purged from the presses to allow more steam to enter, and this is accomplished by traps which discharge to a low-pressure line carrying the condensate back to the hot-well and feed, water heater in the boiler house. The hot-well is vented to the atmosphere; therefore, the condensate having lost pressure from that in the press loses considerable of its heat and weight in "flash-off" through the vent. Cold makeup water is added to take care of this and other losses and the water is pumped back to the boiler to complete the cycle.

If, however, high-pressure hot water is to be used as the heating medium it is unnecessary to go through the vaporization part of the cycle in the boiler. Water that has been heated to 350 deg. F. at 120 lbs. pressure is withdrawn from the boiler and circulated through the mains and presses by means of a pump and returned direct to the boiler still under full pressure. In passing through the presses the water gives up heat and is reduced in temperature a certain amount but not in pressure. One pound of water gives up one B.T.U. for each degree F. drop in temperature so that it is necessary to pass through sufficient water to accomplish the heating with the desired uniformity of temperature. What heat is not used goes directly back to the boiler in the return water,

*J. O. Ross Engineering Corp.

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An oil-hardening tool steel for intricate molds and molds that must hold size to super-accuracy. Hardens to C-61/63 Rockwell, high wear resistance.

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which replenishes what has been used in the presses plus a small amount lost owing to radiation from the insulated mains.

Let us now look at some of the thermal properties of water and steam. We have seen that in the steam boiler both the water before evaporization and the dry saturated steam at 120 lbs. gage pressure are both at 350 deg. F. From the steam tables we find that under these conditions of pressure and temperature the water weighs 55.6 lbs. per cu. ft., whereas steam weighs only 0.3005 lb. per cu. ft.; and, what is important to consider, that one cubic foot of water contains a total heat of 17,870 B.T.U.'s, whereas one cubic foot of steam contains 378 B.T.U.'s. In other words a given volume of high-pressure hot water contains 50 times the heat of the same volume of steam.

Thus we see that the water system acts as an accumulator of heat with a large reserve capacity to take up any sudden loads without reduction of pressure, which in a steam system would mean reduction of temperature. Also, if we make allowance for the difference between the ordinary velocity of steam and that of water in the piping, we find that a given size of pipe will pass five times the amount of heat in water than in steam, thus making for a much greater uniformity of temperature throughout the system and affording the opportunity of using smaller piping and valves.

It has been observed that presses and molds heat up much more rapidly with high-pressure hot water than with steam, which is a matter of importance when molds are changed or after a weekend shutdown, and particularly when both heating and cooling are employed in each curing cycle.

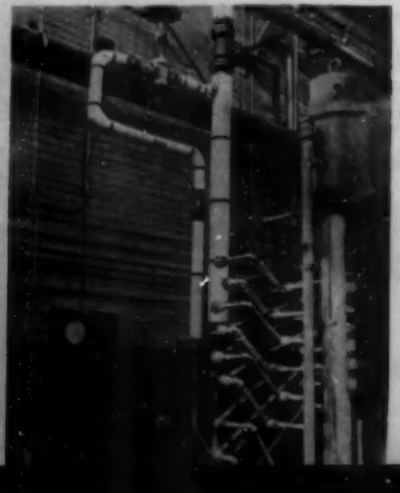
Many engineers consider that steam should have the advantage of maintaining uniform press temperature because with a fixed pressure the temperature of steam is constant until condensation is complete. If it were possible to maintain fixed conditions that would be true but there are operating difficulties tending to offset best results. It is impossible to maintain pressure in all steam lines due to variation of loads and sudden large demands with consequent large drops. The temperature falls with the drop in pressure. Thus we are not assured of a constant inlet temperature. Then when a trap is discharging condensate there is a tendency to reduced pressure and temperature on the outlet. Also air is carried over from the boiler with steam and if this pockets in the presses "cold spots" are found and it is necessary to bypass the trap in order to purge the press of air and condensate, resulting in a pressure drop at the outlet and a loss of valuable heat in the steam used for purging. Traps, even if perfectly maintained, will leak some live steam at times to the return lines. Some or all of these conditions exist in every plant and make it difficult to maintain uniform temperatures.

It is not always possible to realize that these things are taking place and operators think that press temperatures are uniform because theoretically they should be.

In a high-pressure hot water system we have seen that it is much easier to maintain a uniform flow temperature to all parts of the plant. Air that may be entrained in the water at the initial filling of the system is soon vented off and the same water is being constantly recirculated and reheated. This affords positive circulation to all parts of the presses with clean water that is free of air and scale-forming impurities, so that all parts become uniformly heated. Absence of corrosion and scaling means cleaner boilers, piping and platens or molds with better heat transmission. This feature alone is responsible for a great reduction in costs of maintenance and replacement. The elimination of traps, separators, bypasses, condensate collectors and makeup feed water heaters and purifiers contribute to savings and simplicity of operation.

When it is required to change press temperature for changes in grades of molding materials the usual method with steam is to install a pressure reducing valve at each press and this is a simple and effective means. With hot water no added equipment is necessary for moderate changes, for the water flow can be throttled by the press valves and still maintain sufficient uniformity of press temperature. But where the size and design of the molds or platens are such that a large reduction could not be secured with uniformity of temperature, recirculation of a considerable portion of the return water and the admission of just sufficient water from the hot water flow main to maintain the desired temperature will accomplish the desired result.

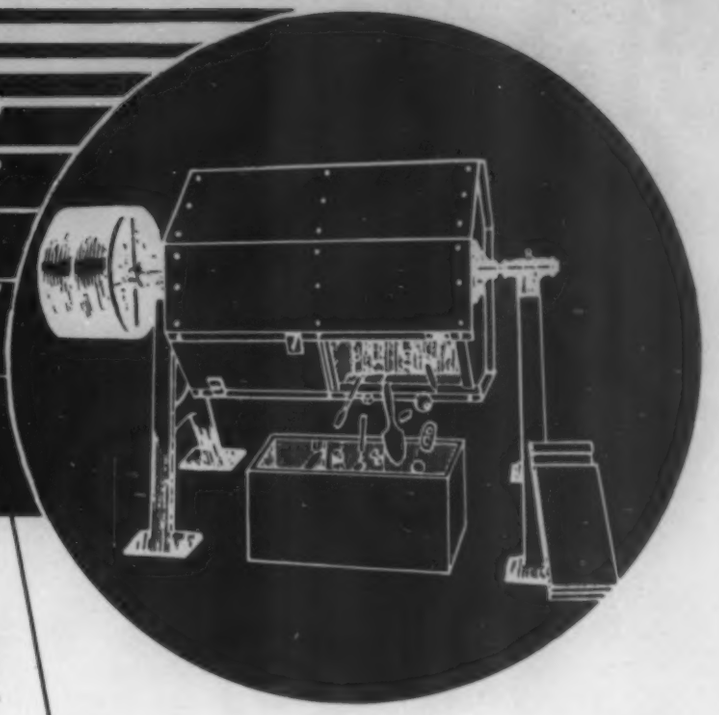
While we have discussed in the foregoing mainly the design and operating features of each system, it has been noted that there are some inherent and operating losses when using steam that are absent from the high-pressure hot water system. It has been found that definite fuel economies ranging from 25 percent to 40 percent or more have been realized in actual molding plants by the use of high-pressure hot water.



At the extreme left is a rod and tube press installed at Synthane Corp., which is heated by the Ross Supertherm system. The illustration beside it shows a sheet laminating press which is heated by the same system

Rudolph R. Siebert

● Originator of dry Barrel Tumbling



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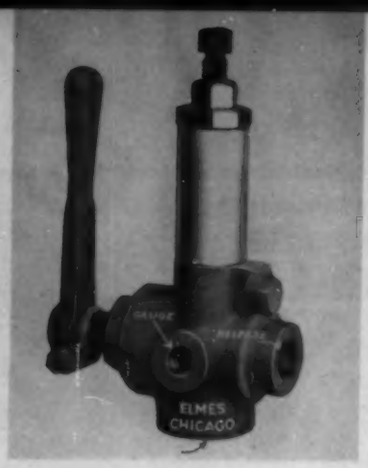

2

Stop, or release, valves are used to operate from a direct connected pump. Fig. 1 shows a valve with horizontal connections at right angles with each other. Fig. 2 is a combination release and safety valve

HYDRAULIC CONTROLS

by CHARLES F. ELMES*

SUITABLE PRESS CONTROL MECHANISM HAS FOR a number of years been a subject of great interest, both to the press user and the manufacturer of hydraulic equipment. In the early days of the plastic molding industry when hand molds were used almost exclusively, the question of controls for the hydraulic plastic molding press was comparatively simple. It was then only necessary for the equipment manufacturer to have in mind the source of pressure supply, that is, whether the press was to be operated from an accumulator system or a direct pumping unit. If pressure was obtained from an accumulator system, the simplest type of stop and release valve was required (Figs. 1–2), although of course in some instances where both high-and low-pressure accumulators were employed, an additional valve was used for automatically admitting high-pressure liquid when the low pressure had reached its limit (Fig. 3). Similar systems are still demonstrating their worth in modern molding plants, by automatically conserving high pressure liquid instead of leaving the change-over from low pressure to high pressure in the hands of the operator.

In the case of the self-contained press, that is, the press with its individual pumping unit—and before the development of the rotary type pump—units similar to that shown in Fig. 4 were often used. In some instances the reciprocating or plunger pump was not mounted on the press, but arranged as a separate unit placed adjacent to the press. With such installations, a simple stop valve was used as a release, and an adjustable type by-pass valve employed to by-pass the pump and maintain pressure during the curing cycle.

These systems apply to the hand mold type of press and therefore, no pressure was required for opening the press at the end of the curing cycle, since the molds were parted after removal from the press.

With the development of what is commonly known as the semi-automatic type of plastic molding press which involved the loading and unloading of the molds without their removal from the press, it was found that additional pressure was required for stripping the pieces from the molds. This necessitated what is commonly known as pullback cylinders on the presses, and the general practice was, and still is in many instances, to float these pullback cylinders on the accumulator line. This of course re-

* Charles F. Elmes Engineering Works

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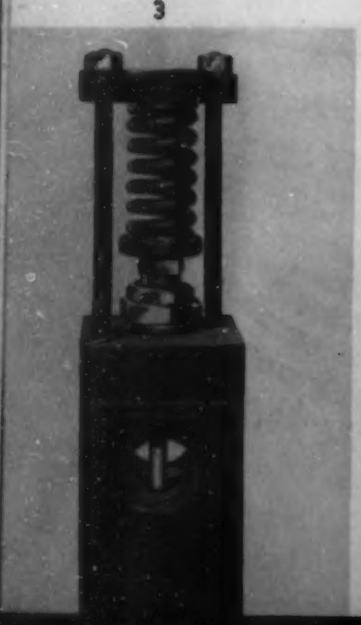

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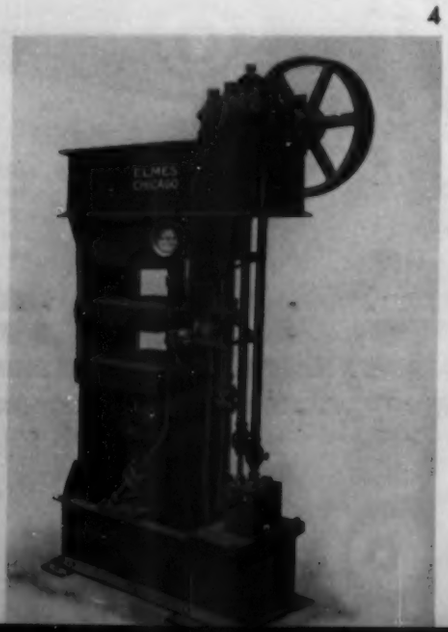
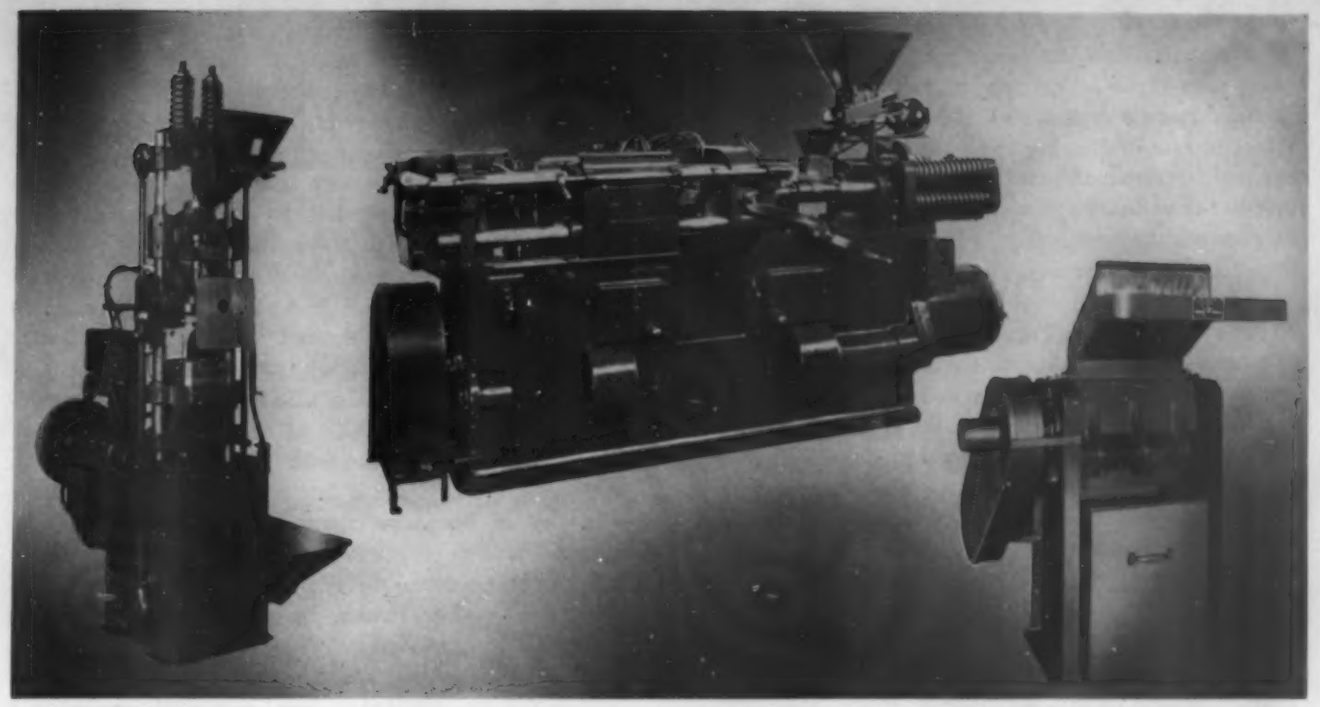


Fig. 3 shows an automatic high- and low- pressure valve designed for admitting high-pressure liquid where the low pressure has reached its limit. Fig. 4 is a hot molding press with a heavy duty type pumping unit



DE MATTIA EQUIPMENT FOR INJECTION MOLDING

Model "D" De Mattia Injection Molding Machine

SPECIFICATIONS

Molded material per injection	4 ounces
Injections per hour	120 to 450
Time for injection stroke	2 seconds
Maximum projected area of molded parts	30 sq. in.
Mold closing force	200 tons
Plasticizing capacity	30 lbs. per hour
Motor furnished	10 H. P.
Maximum Mold size	13½" x 16" 15½" round
Distance between die faces (stroke) when open	7"
Maximum die space	9"
Minimum die space	5"
Floor space required	108" x 30"
Weight of machine including motor (approximately)	7,000 lbs.

De Mattia Two Ounce Unit Injection Molding Machine

SPECIFICATIONS

Molded material per injection	2 ounces
Maximum injections per hour	140 to 500
Time for injection stroke	1⅛ seconds
Mold closing force	80 tons
Maximum projected area of molded parts	18 sq. in.
Motor furnished	10 H. P.
Maximum mold size	12" x 14"
Maximum die space	8"
Distance between die faces (stroke) when open	7"
Minimum die space	4"
Floor space required	35⅛"x 31½"
Weight of machine including motor (approximately)	3,200 lbs.
Plasticizing capacity	20 lbs. per hour

De Mattia One Ounce Unit Injection Molding Machine

SPECIFICATIONS

Molded material per injection	1 ounce
Maximum injections per hour	140 to 500
Time for injection stroke	1⅛ seconds
Mold closing force	80 tons
Maximum projected area of molded parts	12 sq. in.
Motor furnished	7½ H. P.
Maximum mold size	12" x 14"
Maximum die space	8"
Distance between die faces (stroke) when open	7"
Minimum die space	4"
Floor space required	34⅛"x 31½"
Weight of machine including motor (approximately)	3,000 lbs.
Plasticizing capacity	14 lbs. per hour

De Mattia #1 Acetate Grinder

SPECIFICATIONS

Capacity—200 lbs. per hour

3 HP Motor with double "V" belt and Cast Iron Pulleys

Four steel chopper blades with inserted tool steel cutting edges

Best type roller bearings with positive seal

Standard screen with 1/4" openings

Net weight with motor (approximately) 600 lbs.

DE MATTIA high speed injection molding units are fully mechanical in operation . . . they are built to meet the demands of molders to whom time is money.

For complete particulars, write, wire or phone. You are welcome to our full cooperation.

DE MATTIA MACHINE AND TOOL COMPANY

CLIFTON, N. J.

NEW YORK OFFICE 30 CHURCH STREET

Cable Address: BROMACH, New York

quired the use of a three-way operating valve, either of the two-stem handwheel operated type (Fig. 5) or of the single-stem rapid-acting type shown by Fig 6, or the balanced spindle type as shown by Fig. 7.

In contrast to floating the pullback cylinders on the line another common practice is to admit hydraulic pressure to the pullback cylinders only when this is required for opening the press. To do this requires the use of a four-way operating valve, either of the three-stem handwheel operated type, or of the four-spindle type, similar to the valve shown in Fig. 8.

It must be understood that the above mentioned valves are all of the type suitable for installations where water is used as a pressure medium, and that in many instances valves of a simpler and less costly design can be employed where oil is the pressure medium, such as the piston type.

In recent years the perfection of various types of rotary oil pumps has resulted in a number of important and desirable changes in press control mechanisms, and has been instrumental in bringing about the popularity of the self-contained plastic molding press. The use of these pumps has made possible a less costly, more compact press unit, combining pumps, motor and controls in one housing, and presenting a more pleasing general appearance. Such a unit is shown in Fig. 10.

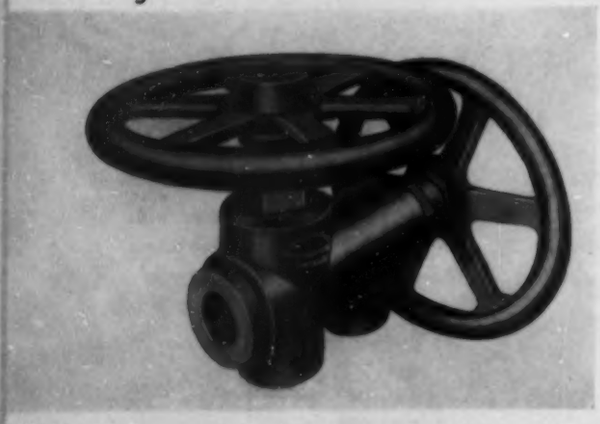
Self-contained presses of the conventional four-column type construction, incorporating the same features of pumping unit, controls, etc., are also used (Fig. 9).

The pumping unit on the modern self-contained press is often of the high- and low-pressure type, employing the use of a large volume low-pressure pump which serves to move the press ram under rapid traverse until the molds are closed. At that point pressure in the system immediately increases, thereby actuating a by-pass valve which allows the low-pressure pump to bypass the oil back to the reservoir. During the press closing period, the high-pressure pump delivery has also been directed into the press cylinder. This pump then continues to build up pressure to the desired point and maintain that pressure during the curing cycle.

In the case of the radial piston type pump, a pump control is usually used which permits this high pressure pump to move over on practically no stroke, which means that the pump is simply delivering a sufficient quantity of liquid to maintain pressure in the press cylinder and to compensate for any leaks which might occur in the system. It will be seen that by moving the pump over to short stroke, the motor is unloaded, due to the small volume of liquid being handled.

An alternate to the above system in which high- and low-pressure pumps are required is that system using a high-pressure pump only, and a rapid advance ram. In such a system the discharge from the high-pressure pump is directed to the smaller or rapid advance cylinder, thereby accomplishing quick closing of the press. While the press is being closed the main or large cylinder is prefilled with liquid through a prefill valve of sufficient size to allow a free flow of the liquid from the prefill tank, the liquid being directed to the prefill valve by the combined forces of gravity and the vacuum created in the cylinder by the ram movement. (*Please turn to page 344*)

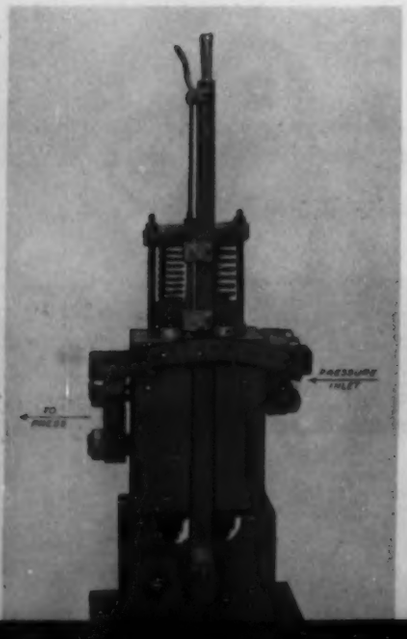
5



A three-way high- and low-pressure operating valve for accumulator systems with single acting presses is shown in Fig. 5, while a three-way single or dual pressure valve is illustrated by Fig. 6. Three-way single pressure operating valve is illustrated by Fig. 7, and a four-way valve appears in Fig. 8

6

7



8

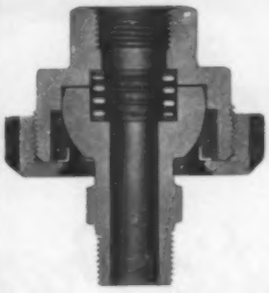
BARCO

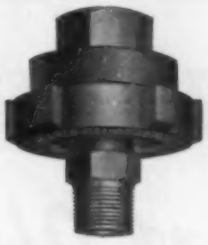
BARCO SWIVEL JOINTS *for leakproof swing*

The fluid tight qualities of BARCO Swivel Joints are unaffected by either alternating heat and cold suction or pressure.

Proof of the sterling qualities of BARCO Swivel Joints is found in their wide use as standard equipment on injection and compression molding presses, platen presses, high quality machine tools, etc., made by leading machinery manufacturers, and their wide use by rubber and plastic manufacturers.

Write today for catalog 257 giving complete details and cost.





Swivel 7S-8CS

Swivel 7S-8BS

Swivel 7AS-8CS

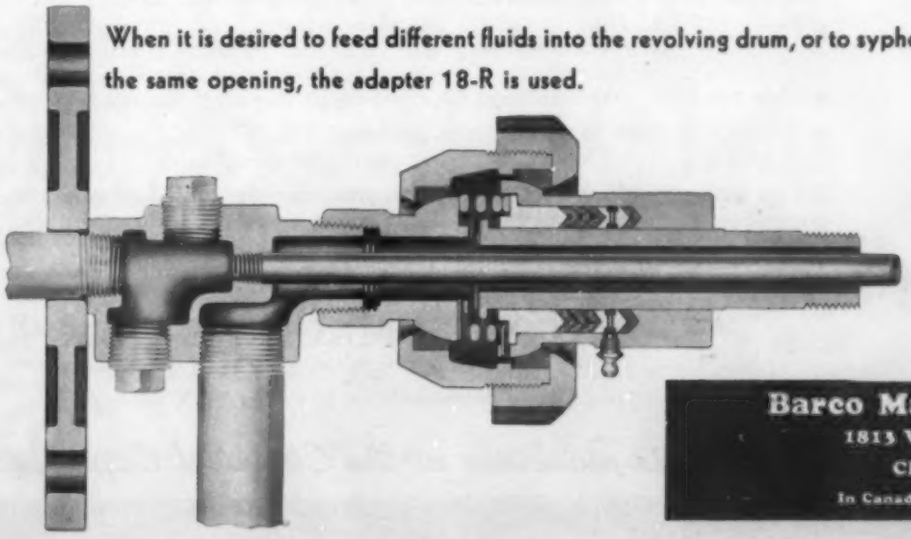
Swivel 7AS-8BS

REVOLVING JOINTS *for free movement in all directions*

Free movement in all directions with trouble-free, long service make BARCO Revolving Joints unique. They are highly desirable for steam, gas and other fluids transmitted between a stationary supply pipe and a rotating drum.

The only part that revolves is the rotating sleeve. This sleeve also slides in and out to take care of end play. The double ball design provides flexibility to compensate for misalignment or eccentric movement.

When it is desired to feed different fluids into the revolving drum, or to syphon condensate out through the same opening, the adapter 18-R is used.



Write today for catalog 291 giving complete details and cost.

Barco Manufacturing Co.
1813 Winnemac Avenue
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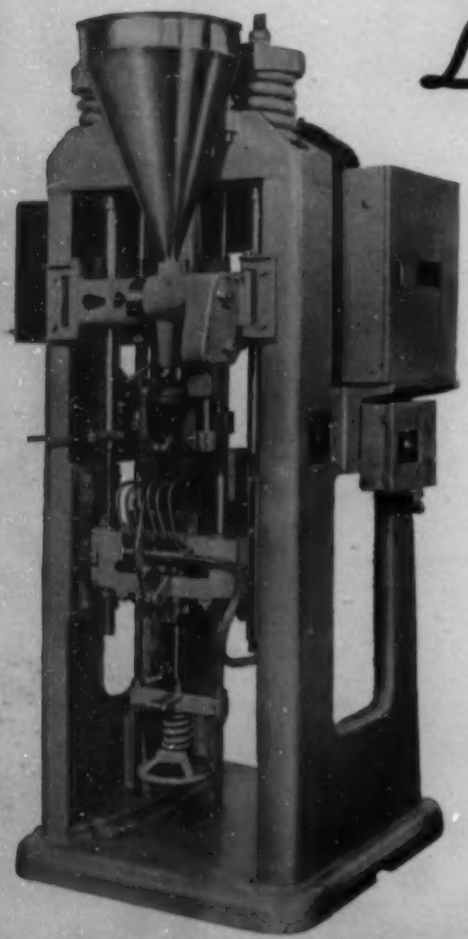
In Canada: The Holden Co., Ltd.

Automatic Molding Produces Lower-Cost Plastic Parts



Stokes Completely Automatic Molding Machine. 15-tons capacity. 10-inches stroke. Other models available.

Now, with Completely Automatic Molding, you can produce plastic parts at lower cost, broaden their application and replace with moldings many stampings, die-castings, screw machine products, etc. No multiple-cavity molds are needed . . . mold savings alone have paid for machines. You mold only as you need parts, keeping inventories at a minimum. You can change product design quickly and at minimum mold expense.

Stokes Completely Automatic Molding Machines produced the typical parts shown above . . . intricate as well as simple moldings, parts with undercuts or side-draws, also threaded parts . . . parts of highest quality, identical moldings, always uniform, always at low cost.

These machines are molding—

- Legs for an electrical appliance, formerly purchased at $15.00, produced at $1.70 per M. (for material, heat, power and direct labor).
- Threaded housings, three at a time, 40,350 per week, unscrewing them automatically.
- One machine saved enough on one job, in 100 days, to pay for itself.
- Automatic screw machine parts that cost $76.00 per M., molded at a cost of only $12.00 for material, heat, power and direct labor.

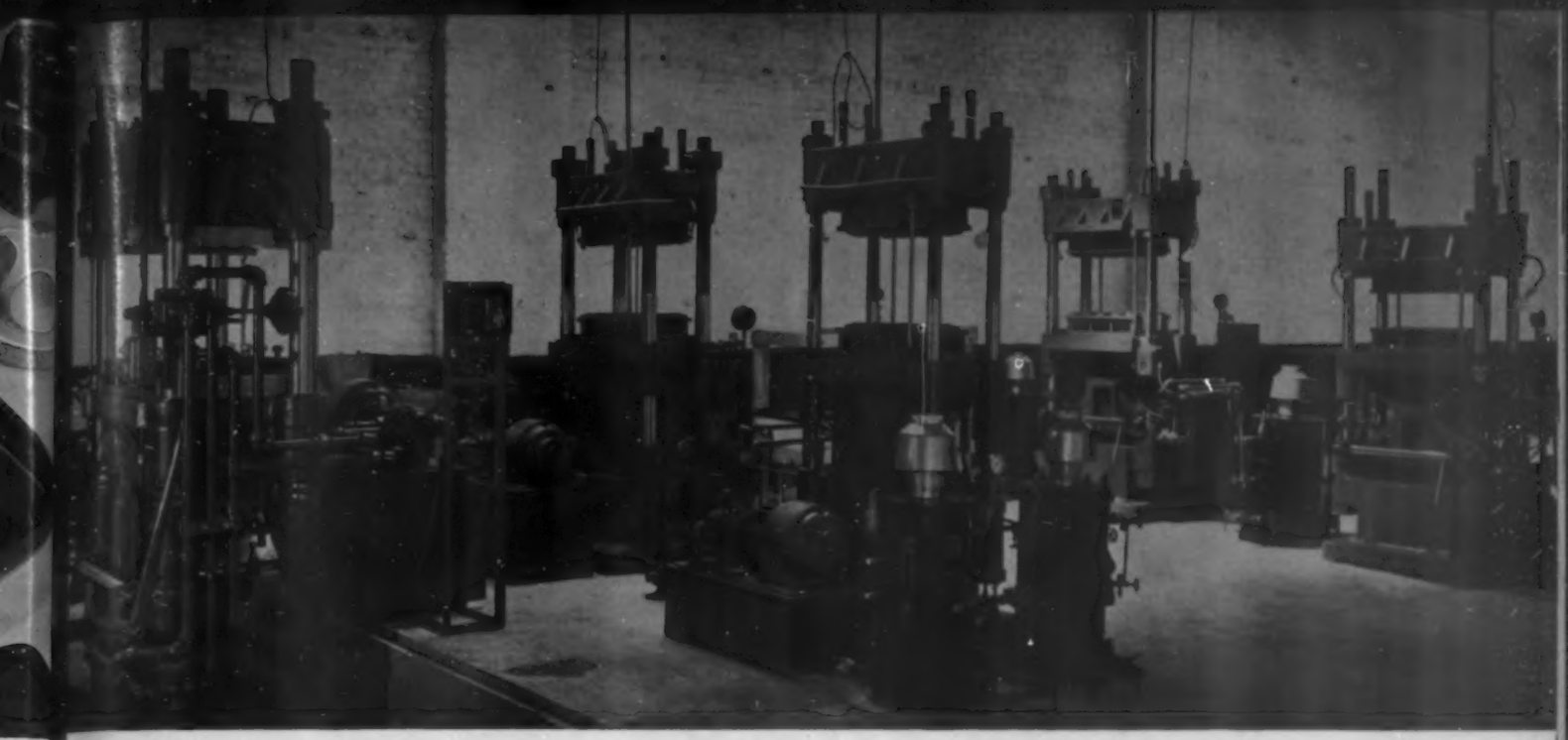
Let us make molding cost studies for you. Simply send samples and state quantities required per year. We'll make typical studies, without cost, without obligation. Write for new catalog and complete information about Automatic Molding.

F. J. STOKES MACHINE COMPANY

Representatives in New York, Chicago, Cincinnati, St. Louis
Pacific Coast Representative, L. H. Butcher Company, Inc.

See these machines at the Chemical Exposition

F.J.Stokes



"Standard" *Semi-Automatic* Molding Presses

Increase Production . . . Improve Quality

For quick deliveries of moldings in large quantities, for general work if molds are already available, for molding larger parts that are beyond the range of fully automatic machines, for moldings with inserts, *use Standard Presses.* These are self-contained, toggle-type, semi-automatic presses . . . modern, productive, labor saving . . . ideal equipment for custom molder and manufacturer alike.

In three new molding plants, within the past three months, Standard Presses and Stokes Automatic Machines have been installed, *exclusively* . . . selected because they make a well-balanced combination, a complete plant, capable of molding all work most economically.

Standard Presses offer all the advantages of automatically controlled timing, curing and breathing. They cut labor costs . . . one operator runs several presses, all he does is load and unload. They speed up production, shorten the time of the molding cycle, increase the number of heats per hour. They produce moldings of uniform thickness and highest quality. The toggle action is ideal for molding . . . fast in the clear, slow in the mold. Toggles lift the platens from the four corners . . . there can be no cocking of mold, no excessive mold wear and tear.

Users say Standard Presses "Doubled the number of heats per hour" . . . "Cut labor cost in half" . . . "Eliminate mold wear" . . . "Negligible maintenance—only $5.00 for nine presses and their molds in one year."

Standard Presses are built in six sizes, 20-tons to 300-tons capacity. Write for complete information.

5934 Tabor Road, Olney P. O., Philadelphia, Pa.

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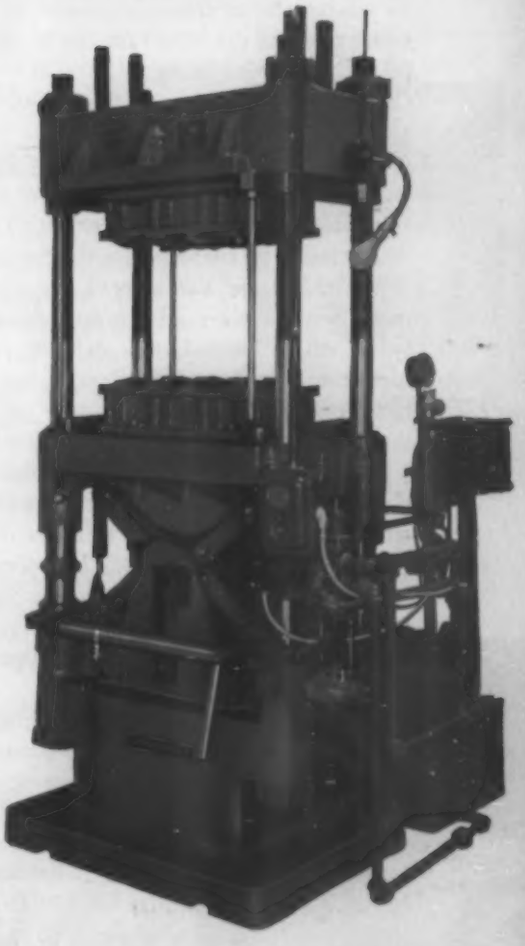
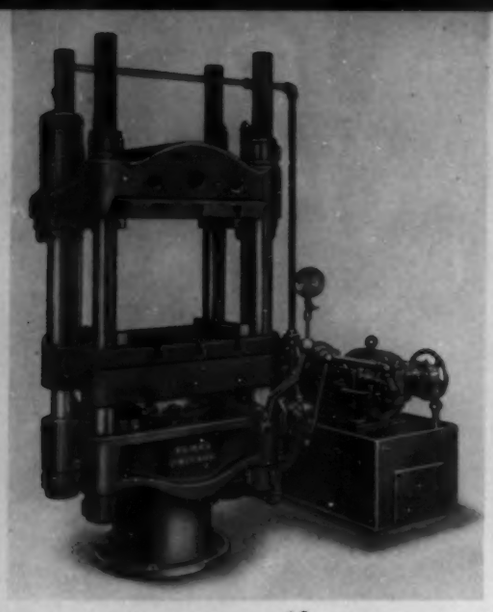


Standard Semi-automatic Toggle-type Molding Press. 150-tons capacity.

MOLDING EQUIPMENT

FJS Est. 1895

9



10

Valves for self-contained presses (Fig. 9) are much more simple than those required where hot water is used for pressure. Rotary pumps (Fig. 10) sometimes supply oil pressure to conventional presses

(*Continued from page 340*)

In describing the cycle of the self-contained unit, it was stated that the low-pressure pump by-passes after the molds have been brought together and pressure starts to build up. In some instances it is not desirable to bring the molds together under the rapid advance speed. It is then possible to actuate the low-pressure by-pass valve by mechanical or electrical means, so that the rapid advance speed of the press ram can be cut off at any desired point, this point being adjustable. When this occurs, the high-pressure pump continues to move the press ram at a greatly reduced rate of speed, thereby closing the molds gently and without shock. The time cycle control which is now in use on many presses is simply a standard make of electric timer which can be set to maintain pressure on the work for the required length of time. When this time has elapsed, an electrical contact is made with a solenoid-operated four-way piston type valve which immediately exhausts pressure from the main ram and directs the flow of the pump to the pullback cylinders—or, in the case of the double-acting ram, to the pullback side of the main ram.

As in closing, it is sometimes also desirable to open the molds slowly for a short distance, in order to protect inserts, etc. A similar means to that described above can be used for actuating the low-pressure by-pass valve, so that the large volume pump discharge is not directed to the pullbacks until the molds have been opened the desired distance. The press then opens under the rapid advance speed.

An addition to the fully automatic control system may be had where it is desired to automatically breathe or gas the molds. This makes it possible to automatically part the molds after a predetermined lapse of time, and then immediately close the molds and continue with the curing cycle. In addition to the automatic breathing control, similar mechanisms are used for controlling the admission of steam to the molds, as well as the admission of cold water where chilling is desired.

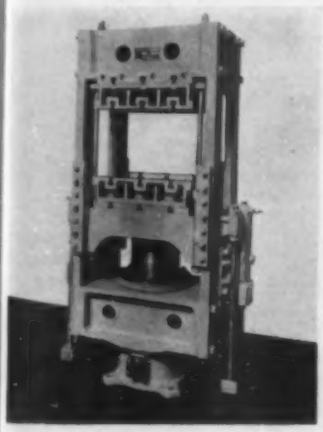
In summarizing, it will be found that molding presses can now be equipped with such control mechanisms that the operator, after filling the mold cavities with the material has simply to push a single button, automatically starting a complete cycle which can include all of the various steps that may be required in handling the more difficult type of pieces. This leaves the operator free to proceed to the next press and perform the necessary unloading and reloading operations.

Although practically all of the above description has dealt with control mechanisms, power units, etc., for the self-contained type of molding press, we should not overlook the fact that a majority of the presses now in operation are provided with both low- and high-pressure liquid from accumulator systems. Space does not permit a discussion of the various types of accumulator systems available, i.e., weighted or gravity—hydro-pneumatic—and air ballasted types. This latter is considered by many manufacturers as being particularly adaptable for plastic molding service.

The type of control valves used is governed principally by the type of liquid employed as a pressure medium, i.e., oil or water, but it may also be said that similar automatic control systems can be obtained for accumulator-operated presses. This valving will necessarily vary in certain details, but the electrical circuits for actuating main operating valve, controlling the breathing and time cycles, closing and opening speeds, are essentially the same and it is simply a matter of furnishing the necessary mechanism for actuating the valves which control the press movement, whether these actuating mechanisms be in the form of electric solenoids, small hydraulic cylinders, air cylinders, or diaphragms.

It is for the press user to determine the most suitable type of control for the equipment in his plant. Consideration should be given to the type of work that is usually run in his presses, which of course involves the matter of loading time, curing time, etc., together with the original cost of the various available control mechanisms, and the maintenance of same, since it may be understood that for some classes of work a too elaborate and too costly hydraulic control system would not be advisable.

This group of parts moulded on Lake Erie presses by Norton Laboratories, Lockport, N. Y., illustrates just a few of hundreds of products which have worked industrial miracles in sales appeal, strength and economy.



One of 16 standard sized semi-automatic Lake Erie Moulding Presses built in either four column or latest side plate design available in self-contained or accumulator types with spring or hydraulic strippers.

Moulders Are Doing It Better With Lake Erie Hydraulic Moulding Presses

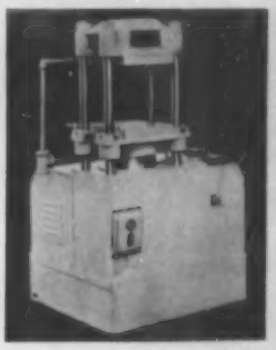
In today's battle of product improvement, plastics are probably the most-talked-of man-made material. Practically one-operation conversion from raw material to completely finished products throws heavy responsibility on the presses that are performing these industrial miracles.

70 years of Lake Erie Engineering experience is helping one of the world's newest industries make profits from ultra-modern products.

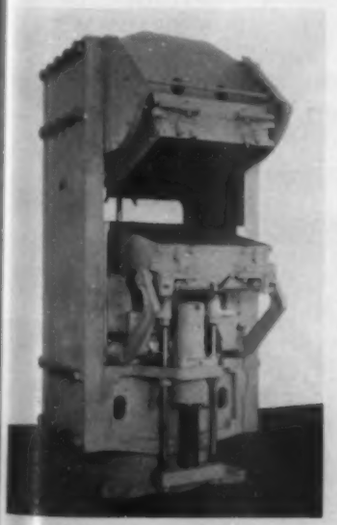
Plastic moulders are taking advantage of the complete Lake Erie line of presses for fast economical production of widely varying sizes, shapes and types ranging from laminated sheets to intricate one-piece finished products.

These photographs show just a few of the many Lake Erie Hydraulic Presses serving moulders and manufacturers everywhere.

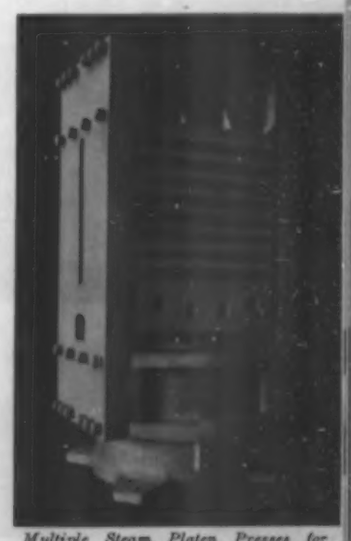
You are invited to "put it up to Lake Erie" and benefit from the wide and diversified experience of our engineers in designing, building and applying hydraulic presses for production of plastic products. An outline of your requirements will receive expert attention.



Streamline Hand Moulding Presses with compact self-contained pumping units include sensitive pressure and speed controls.



Lake Erie 1000 ton Hydraulic Moulding Press with tilting platens and automatic multiple ejection, for use with



Multiple Steam Platen Presses for making laminated plastic sheets. Built in all tonnages to provide the most economical type and size for every produc-

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ENGINEERING CORPORATION

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I.M.C. LESTER DESIGNED INJECTION MOLDING MACHINES HAVE

75% OF ALL SALES HAS RESULTED IN REPEAT ORDERS

Progress in plastics has been little short of phenomenal. Never before has the demand for adequate equipment to meet such unprecedented growth been so great. I.M.C., with its Lester Designed Fully Automatic Injection Molding Machine, more than meets this demand. With a background of more than 20 years experience behind its design, is it any wonder that, today, I.M.C.'s machines are the recognized leaders in the field.

Keeping pace with the Industry's growth, the number of I.M.C. Lester Designed machines in use has doubled in the last year. Even more significant, *75% of all sales has lead to repeat orders.* These two facts speak for themselves. They are proof that I.M.C. is meeting the growing requirements of the plastic industry and is providing dependable, trouble-free operation under a wide range of conditions.

I.M.C. Offers These Superior Features

I.M.C. Lester Designed Machines, built upon a background of more than a score of years experience in the pressure casting field, offer these outstanding advantages:

ELIMINATION OF FLASH

Extremely heavy cast steel beams actually forming a box construction, by which tremendous mold holding pressures are possible, coupled with the positive locking of the molds through the famed patented toggle lock mechanism combine to completely *eliminate flash.*

RAPID MOLD CHANGE

Positive adjustment of die plates, through a patented worm and worm wheel movement. Guesswork entirely removed. Mold changing is but the work of minutes instead of hours and without the necessity of a skilled mechanic.

OPERATING FLEXIBILITY

A volume control unit is used in the plunger cylinder circuit providing complete control of the injection speed without affecting injection pressure. A pressure reducing valve provided in the injection cylinder circuit provides easy control over the pressure without affecting the speed. These two features give easy, dependable control over two of the most vital factors involved in injecting various thermoplastic materials. Consult an I.M.C. user and learn, first hand, how smoothly these features operate.

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An I.M.C. Lester Designed Machine of the higher capacities, frequently makes the installation of additional equipment unnecessary. Extra cylinders of various capacities may do the job. I.M.C. machines are built to provide quick and easy access for changing cylinders, to meet pressure and capacity requirements.

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Less than one second required to complete actual injection of maximum casting of 100 sq. in. . . . speeds up to 245 inches per minute . . . pressures in use up to 35,000 pounds and higher pressures upon application or to meet demands of various materials . . . pump installations up to 93 gallons per minute with corresponding motor requirements. These are a few of the I.M.C. Machine highlights. Full details upon request.

WIDE RANGE OF CAPACITIES

Standard machines consist of 4, 6, 8 and 12 ounce capacities and are quickly available for delivery. Special machines of varying capacities built to order.

ENGINEERING ASSISTANCE

I.M.C., through its own engineering department and through the Lester Engineering Company, designers, will welcome the opportunity to help with your molding problems. Production estimates gladly given without obligation.

WE INVITE YOUR INQUIRY

Let us work with you on problems of injection molding. Write us for further details. Your inquiries will be acted upon at once. Before you purchase additional machines be sure to investigate I.M.C.'s line of Lester Designed Machines.

AN ACKNOWLEDGMENT TO I.M.C. USERS

Index Machinery Corporation acknowledges to the users of its Lester Designed Machines the many fine expressions of full satisfaction that are regularly received. As further evidence of this satisfaction, it is indeed gratifying to I.M.C.—a Pioneer in Injection Molding in the United States—to realize that approximately 75% of Lester Machine sales has resulted in repeat orders. It is this confidence and faith in its proven equipment for which the Index Machinery Corporation wishes to express its appreciation.

INDEX MACHINERY CORPORATION *49 Central Ave. Cincinnati, Ohio*

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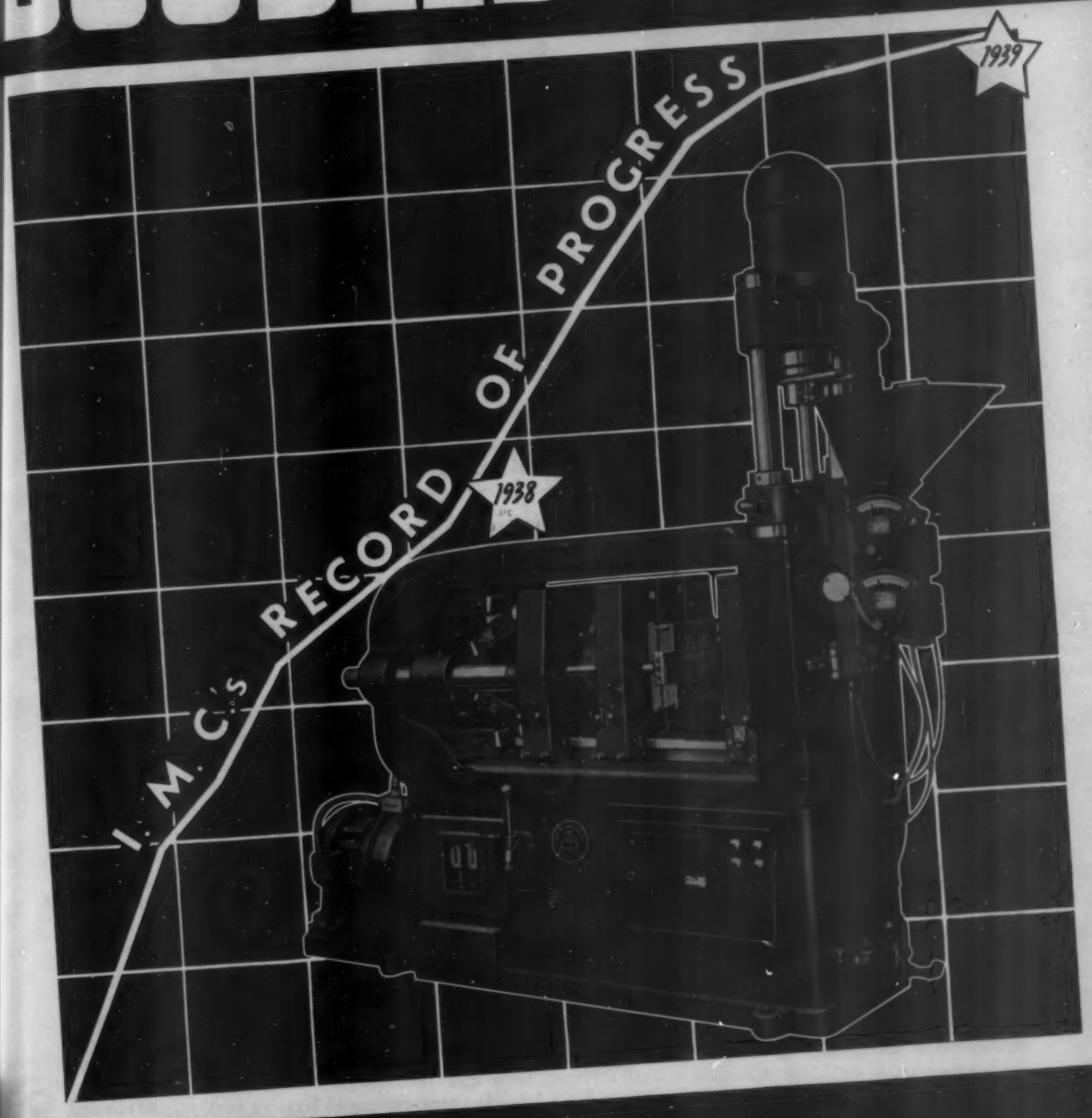

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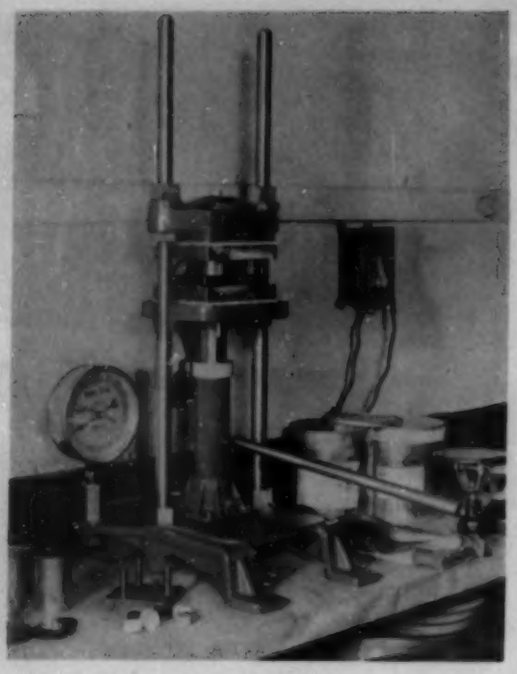
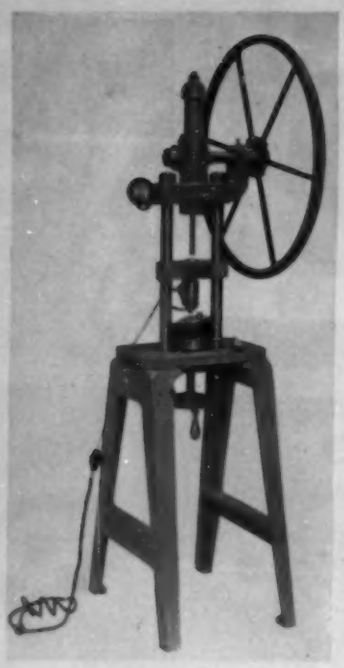
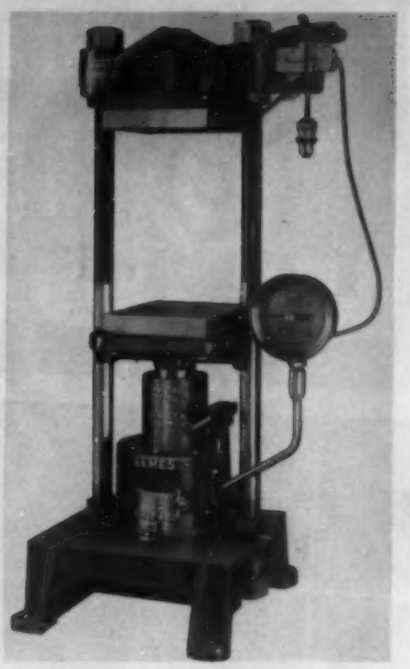






Laboratory presses of many kinds are available for testing and experimental work. Even small production runs are turned out occasionally in these accurate and efficient presses. Those above, left to right, are made by Fred S. Carver; Evarts G. Loomis; and Charles F. Elmes Engineering Works

LABORATORY PRESSES

by FRED S. CARVER*

NOT LONG AGO, SOMEBODY SAID IT WAS GETting so that whenever a chemist got an accidental reaction and found a sticky mess in his retort, he would immediately get busy to see whether he hadn't found another new plastic. This was probably quite true and is still going on, more than we know.

But today there are many plastics, of many desirable characteristics, colors, and applications, for different uses, highly developed and still developing in ever-broadening fields. Not only development of these plastics, but of their applications and uses in producing a multitude of new things, goes on continually, and in these fields laboratory presses play a most important part.

Laboratory presses have been developed and used which enable the chemist, the research man, and the production man, who work out, develop, and control the characteristics and uniformity of the different plastics, to run actual small scale molding tests in the laboratory, on samples and control batches. These same presses provide, too, for making molded samples of finished pieces, first through experimental production in single cavity molds, and often production in small scale multiple cavity molds, up to the point of sales.

* Fred S. Carver.

Then if the product is right, it is ready for quantity production in the plant, by means of large presses and multiple cavity molds; and this is where plastic molding truly comes into its own.

These small laboratory presses have been designed so that openings are quickly adjustable by hand to suit different experimental dies. They are provided with electric hot plates to suit the thermosetting materials, or with steam hot plates, which provide for steam heating and water cooling, to suit the thermoplastic materials.

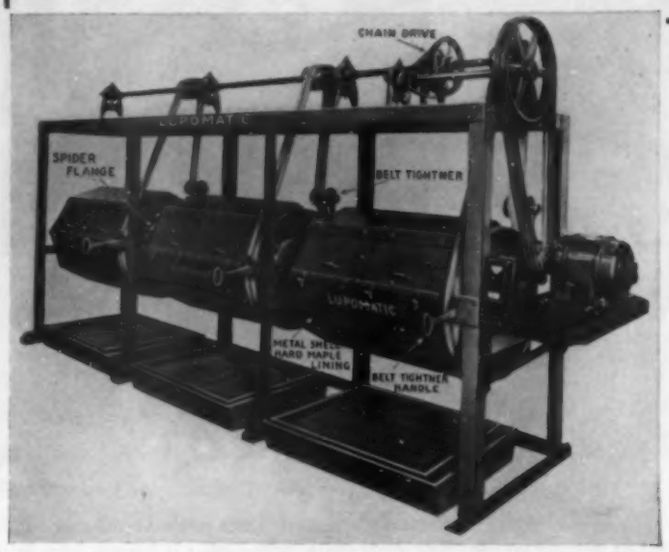
It is important that the presses be hand-operated, provided with pockets for laboratory thermometers, large accurate gages, and hydraulic means such that moldings may be made accurately under varying conditions of pressure, time, and temperature, as required. And for these purposes, within limits, the smaller the press the better, because of its ease and speed of operation and adaptability for many purposes.

It will be seen that with such a press, small scale tests are made and samples produced which mean much in guiding and controlling further operations. Not only molding, but extrusion and plasticity tests, laminations, etc., and even crushing or breaking tests, may be run on the same machine. *(Please turn to next page)*

Here's

Quality – Economy – Service

For Manufacturers of Plastic Products



LUPOMATIC'S ENGINEERING SERVICE
LUPOMATIC'S FOOLPROOF COMPOUNDS
and the IMPROVED LUPOMATIC PROCESS
give the Plastic Industry just what it needs.

A QUALITY FINISH
PERMANENCY OF LUSTRE
EASE OF APPLICATION
AND ECONOMY

For SERVICE — QUALITY — ECONOMY let your Purchasing Agent specify:

"LUPOMATIC EQUIPMENT and LUPOMATIC TUMBLING SUPPLIES."

Lupomatic Motor Driven Type F 3 Tumbler Unit. Lupomatic Tumbling Units can also be had in double deckers with 2, 4 and 6 tumblers. Our Engineering Dept. will gladly recommend a set-up tailored for your particular needs.

This modern plant is located in New York City. Here we operate an up-to-date machine shop, wood working plant, Laboratory, Experimental and Engineering Dept. all under one roof.

Our plant in New Hampshire produces all the wood pegs, compounds, sawdust and wood linings for tumbling barrels. Full control of raw materials enables the production of QUALITY PRODUCTS at low cost.

* * * * *

Let us demonstrate this money saving process to you gratis. Write us today.

LUPOMATIC TUMBLING MACHINE CO., Inc.

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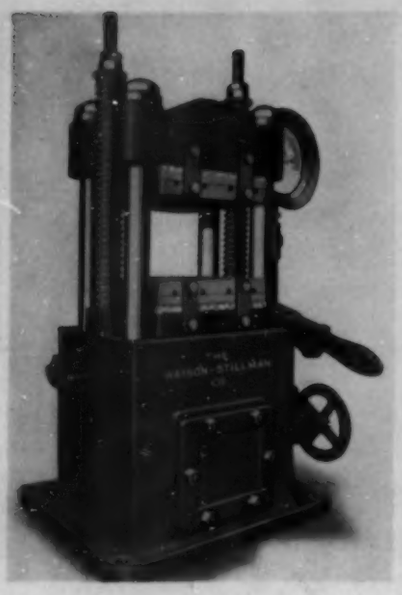
Leaders in the Field of Tumble Finishing



The variety and types of laboratory presses are almost without limit. Watson-Stillman Co., made the one shown, upper left. That in the center is an H. P. M. laboratory press designed and built by the Hydraulic Press Mfg. Co. It has a maximum capacity of 30 tons with a platen surface of 12 in. by 12 in. The French Oil Mill Machinery Co. made the 50-ton laboratory press at the extreme right which is equipped with steam-heated hot plates with flexible steam connections. R. D. Wood Co., built the 30-ton HydroLectric laboratory press at the left. Pressures from 2 to 30 tons may be exerted

There is perhaps no absolute dividing line between the laboratory press and the production machine. Larger presses are of course often required in the laboratory. However, these are usually production or semi-production machines, necessarily used in the laboratory when the tests and research work are run on pieces which are particularly large in size.

But in general we think of the laboratory press as the one best adapted to quick, accurate, small scale tests in the laboratory. And it will be plain that in plastic molding, facts of a test on a few square inches of mold area, or a few cubic inches of material, may be quite accurately translated into large scale operations.

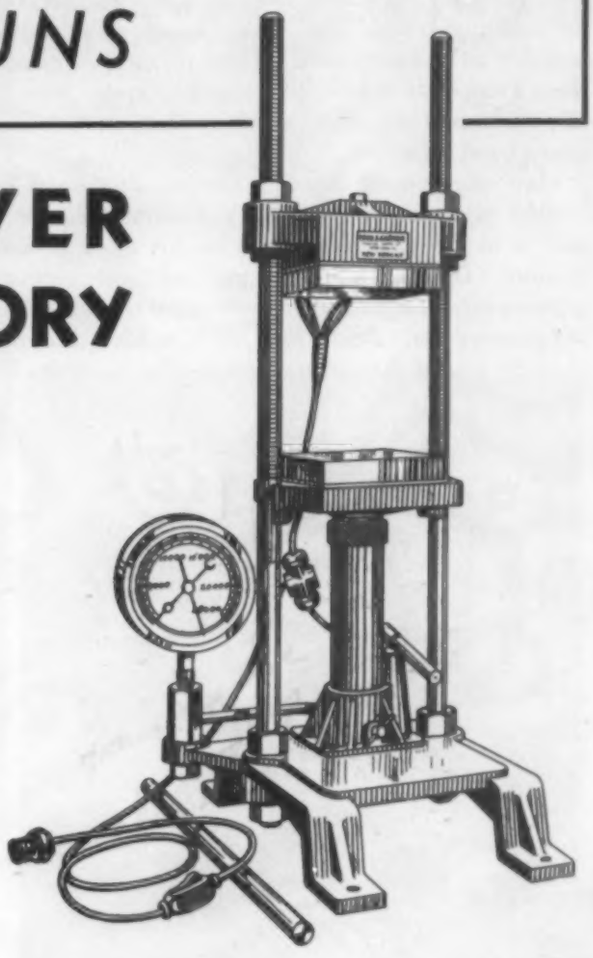
When the required load, time, temperature, etc., are known, for molding a single piece in a single cavity die, then the multiple cavity die and capacity of the large production press for the particular piece can be accurately calculated to best advantage.

In many cases these little presses have been used in actual quantity production with multiple cavity dies for making such things as unbreakable watch crystals and various other small pieces.

In some of the largest plants where there are great installations of production presses, the little laboratory presses are needed just the same, and found most useful. For instance, one of the largest concerns has something like a dozen of them in its different laboratories and plants, for such requirements as samples, testing single cavity molds, and control work. The same is true of other large plastics producers, and of smaller firms and individuals producing plastics and plastics items.

Everybody, everywhere, seems to be using the little laboratory press. It is working on the Malay Peninsula on rubber and other plastics projects, and in the jungle of Brazil, strange as that may seem. They are still being shipped to China in spite of that country's difficulties.

HOW TO MOLD
SAMPLES
TEST BATCHES
SHORT RUNS



The CARVER LABORATORY PRESS

Give a world of opportunities to your research and testing staff—and to your own inventive talents—by installing an inexpensive Carver Laboratory Press.

On just such compact, powerful little Carver Presses, many of the great plastic materials . . . highly profitable new molding techniques . . . and well-known plastic applications were first developed.

Weighing only 125 lbs., the Carver Laboratory Press is a self-contained, hand-operated unit. It was developed especially for plastics reseach, and testing. It provides graduated pressures from 0 to 20,000 lbs., with accurate gauges; temperatures up to 400° F., by means of electric or steam hot plates, with thermometer pockets.

Molders, plastics users, material makers, universities and testing laboratories in all parts of the world are using Carver Laboratory Presses to their great profit. Write for complete catalog.

FRED S. CARVER

HYDRAULIC EQUIPMENT

Est. 1912

343 HUDSON ST. NEW YORK

IN LONDON BAKER PERKINS, Ltd.

MOLDING PLANT EQUIPMENT

WHEN ORGANIC PLASTICS WERE BORN SOME seventy-five years ago, it immediately became necessary to figure out ways and means of converting these new materials into useful products. Like the small boy who inherits his older brother's trousers reefed in here and there and cut down to his size, early plastics were handled with the same equipment that had been in general use for molding shellac and rubber compounds, slightly modified to fit their needs. These plastics, supplied in sheet form, were thoroughly heated to make them soft and pliable and shaped in a specially prepared mold fitted into a hand press.

Then came plastic molding compounds ground into powder or sugar-like granules and suitable equipment had to be devised to take care of this more advanced product. Dies had to be redesigned and toggle-type compression presses replaced hand presses for the job of forming plastic parts. Before long, early molders discovered that the greater the compression, the better the molded part—the harder it became, the more resistant to moisture—and recognized the need for hydraulic pressure which was more even than toggle pressure could ever be.

From then on, a properly and efficiently operated molding plant has required, in addition to actual presses:

Boilers—of sufficient capacity to service the number of presses installed. It takes a great amount of heat and pressure to convert a cup of molding powder or a thick round pill into, say, a box or bottle cap. The heat must be intense enough (from 250 deg. to 350 deg. F. depending on the type of plastic used) to blend the material into a lumpless, viscous mass.

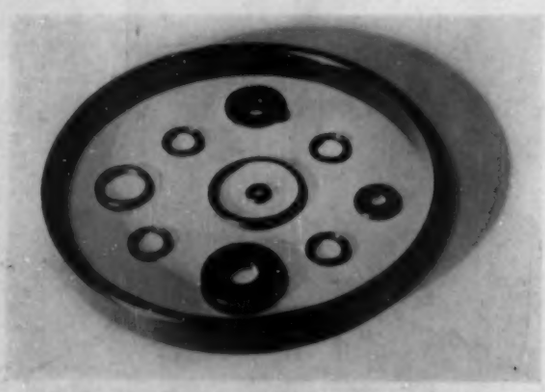
Either steam or hot water, electricity or gas may be chosen to supply this heat to press platens. Steam is probably the oldest method and the most generally used of the lot, especially in large plants where a quantity of presses are operating more or less continuously. It is generated by a centrally located boiler unit and controlled at each press by a steam reducing valve that admits just the right amount to properly heat the mold. As the steam condenses the moisture is drawn from the mold through individual steam traps and returned to the boiler.

Mold heating by hot water, a system that is comparatively new in this country, has been adopted by several of the newer plants. This, too, requires a conveniently placed boiler from which hot water is relayed to the presses, does its job of heating and is returned under full pressure in a closed system—no traps are necessary at the molding presses.[1]

Because even, steady heat is so important, automatic firing of the boiler is practically indispensable. Where oil or gas is used as fuel the boiler, of course, is equipped

[1] See article "Heat for Molding," page 334.

1



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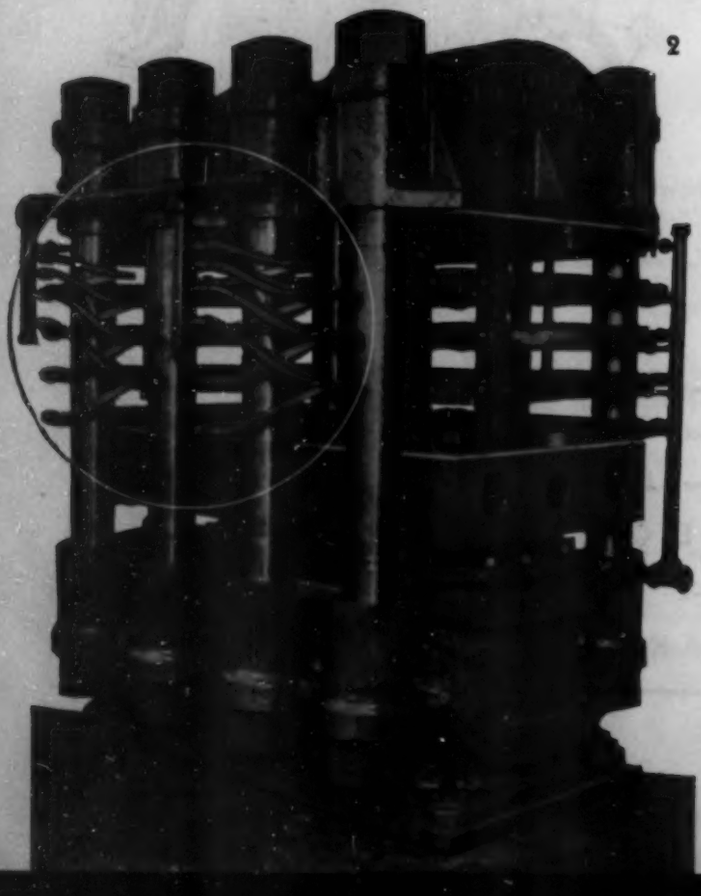
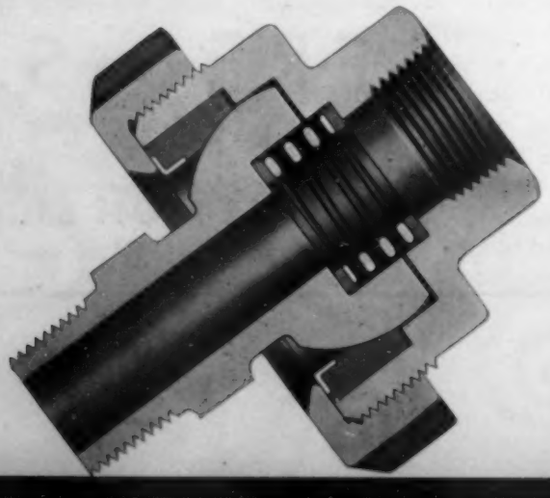


Tough leather packings are required to withstand the terrific wear and tear of the constant motion of the press ram. These (1) are Tannate packings, produced by J. E. Rhoads & Sons. Flexible metal tubing (2) or swivel joints (3) used to convey steam and cold water alternately from the main lines to the press, must be capable of resisting sudden temperature changes. (Photos, courtesy American Brass Co., American Metal Hose Branch, and Barco Mfg. Co., respectively)

3



HAWKRIDGE STEEL

Developed Specially for Plastic Mold-Making and for Sheet Polishing.

HAWK BRAND POLISHING PLATES for FINER FINISHES

Will bring a finer, more perfect luster to your flat plastics sheets. HAWK BRAND Polishing Plates have a mirror finish unsurpassed for quality and perfection.

"HAWK" MOLD-MAKING STEELS

Every type of special carburizing mold steels for deep-hobbing, easy-cutting, and particularly long-lived oil hardening steels. There's a "HAWK" steel made especially for every mold requirement. Write to us for complete data.

HAWK BRAND STEEL

HAWKRIDGE BROTHERS CO. 303 Congress St., Boston, Mass.

4

(4) Oftentimes heavy steel molds are transported from storage racks to all parts of the plastics molding plant by means of overhead cranes. The Northern 5-ton electric crane illustrated is in the press room of General Electric Co.'s Plastics Department

5

In the same plant, a small storage-battery truck (5) is used for the strenuous work of raising bulky dies to the level of the press opening and placing them between the platens. It is also helpful for removing dies after a run has been completed

with automatic controls. The majority of coal burning boilers are fired by automatic stokers to guard against the variations in temperature that are bound to occur every time the door is opened to shovel in coal by hand.

Although centralized heating units predominate, like everything else pertaining to a molding plant, they are not universal. There are shops where each press is supplied with heat by a small individual gas-fired boiler. This permits the operation of one press or a dozen without any heavy boiler installation. One molder has eliminated all steam connections by attaching a miniature, electrically heated boiler to the back of each press. The little boilers cut on and cut off automatically and the temperature can be controlled to close limits. The only use these shops make of a larger boiler is for heating the factory and office in the winter.

Hydraulic equipment—to open and close the presses and apply pressure. The usual procedure is to close the mold slowly at low pressure (250 to 500 lbs. per sq. in.) giving the plastic material time to heat and soften thoroughly before the high pressure (2000 to 3000 lbs. per sq. in.) cuts in, forcing the viscous substance into every nook and cranny of the mold that imparts shape and form to the finished piece. After the proper amount of curing time has elapsed and before the pressure is released, cold water, in some instances, is allowed to flow through channels built into the die, chilling the molded part for ejection.

Both high and low pressure lines are actuated by an accumulator, which hoards pressure to be drawn upon as needed; a pump, which forces enough liquid into the accumulator to keep it well charged; and controls, which regulate the admission of this element at each press.

Any one of several different types of accumulator may be chosen depending somewhat upon the size of the shop and the space that is to be allotted to it. There are weighted accumulators—one has a vertical ram loaded with cast iron or concrete blocks, the number of which may be varied for different operating pressures; another has a tank filled with iron ore, steel punchings, pig or scrap iron, etc. Because of the tremendous weight of these particular pressure storehouses, they must be set up on a firm foundation. A compressed air ballast type of accumulator, charged with air and filled with liquid to the required working pressure, requires no special foundation for installation. For small shops there is an air accumulator, said to be the only one of its kind in existence. It occupies no more space than a small molding press and operates on a 15 H.P. motor.

The pumps that service the accumulators may be horizontal or vertical, whichever fits best into the layout of the equipment. Belt or motor driven reciprocating pumps of two, three and four plungers are popular for supplying high pressure liquid with a centrifugal pump for low pressure. There are some steam driven pumps that take care of both high and low pressure lines.

Control valves at each press may be manually or automatically operated but the consensus of opinion is that automatic controls make for more accurate timing and better molded pieces.[2] (*Please turn to next page*)

[2] See article "Hydraulic Controls," page 338.

FRENCH HYDRAULIC PRESSES

. . . the choice of Leading Plastic Molders

The French Press shown at right is a complete self-contained hydraulic molding press of rigid, accurate construction. Equipped with time control that is fully automatic and instantly adjustable. Modern presses of this design, in various sizes up to 1500 tons, are now used by the nation's leading manufacturers.

For economical production consult French engineers. Write for recent catalog "Modern Hydraulic Presses."

A group installation of twenty self-contained FRENCH OIL POWER Plastic Molding Presses.

French also builds standard accumulator operated presses of many different types. As modern in results as in appearance.

THREE TIMES HONORED

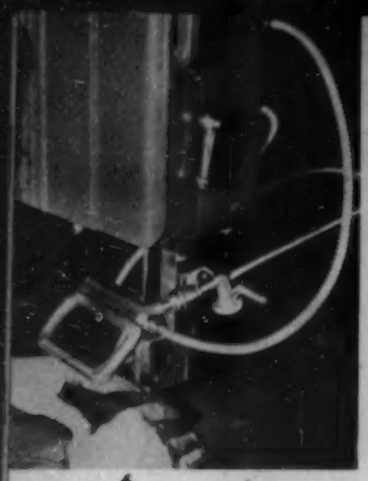
Each year one or more winners in the Modern Plastics competitions used French Presses.

1936
1937
1938

HYDRAULIC PRESS DIVISION

THE FRENCH OIL MILL MACHINERY CO.

PIQUA, OHIO



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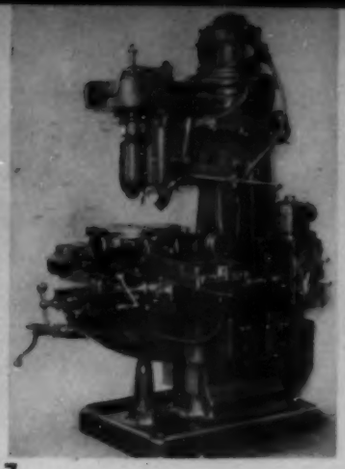

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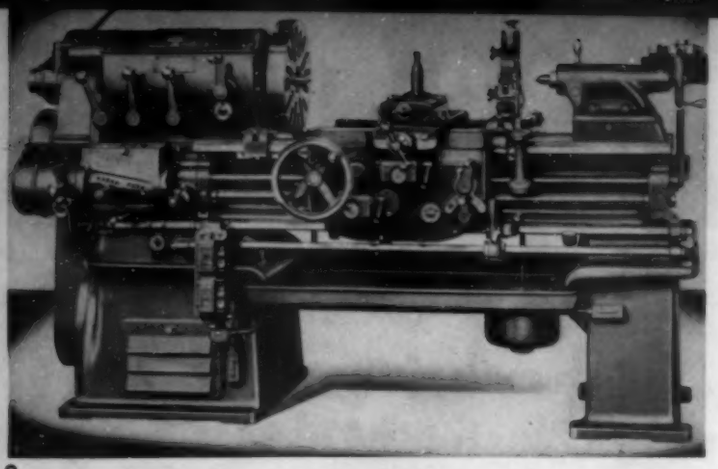


8

An illuminated magnifying glass (6) developed by Continental Machines, Inc., provides additional light for precision work while it doubles the width of the layout line. A vertical milling and die sinking machine (7) is standard equipment in shops making their own molds. A 14 in. by 30 in. 16 speed sliding gear tool room lathe (8) has a self-contained motor drive with taper attachment, collet attachment and collets, oil pan, pump and piping. (Photos, courtesy Reed-Prentice Corporation)

Air compressors—to supply a constant volume of air in any part of the shop wherever its function is desirable: at each press, to blow left-over particles from the mold between cycles, and sometimes to help eject molded parts; at finishing machines, to remove grindings and dust from molded pieces and working surfaces; in the pilling room to clean preform presses and their surroundings between runs of different colored materials. Where an air ballast accumulator is employed, the air compressor gives the unit its initial charge and makes up any losses of air that may occur from time to time.

Water salvage system—to reclaim the vast quantity of water necessary in conducting molding activities and prepare it for re-use through regular channels. Because in certain sections of the country water represents a considerable item of expense, some shops find that it pays to install appropriate salvage equipment. This helps bring the cost of water to its proper level among other operating expenses.

A compact system of piping—to carry steam, low hydraulic pressure, high hydraulic pressure, cold water and compressed air from their source in the power plant to the particular sections of the shop where they are used, together with hydraulic, condensate and warm water return lines. Piping in early shops more often than not resembled a huge octopus suspended from the ceiling with a confusing network of limbs spread out in all directions. Overhead piping is still considered good practice by some, but the lines are arranged in even, direct formation and a color code is usually adopted so that it is an easy matter to tell one line from another. Underground piping is another favored method of installation. The pipes are carried along in a trench that may be covered with boards making this section level with adjacent flooring. The boards, of course, can be removed whenever maintenance work is necessary. By a third method, pipes are arranged horizontally in parallel lines behind a row of presses or perhaps between two rows of presses placed back to back. A trench directly below catches and disposes of any drippings there may be, making it possible to keep the floor clean and dry at all times.

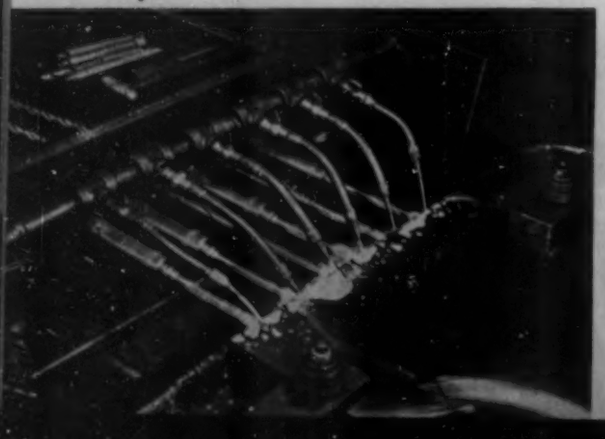
Flexible metal tubing or swivel joints—to convey steam and water from the main lines to the press, and return. The conveyors chosen must be capable of withstanding quick changes in temperature as first steam, then cold water, pass through them. They must be pliable, to bend and straighten with the continuous up-and-down movement of the press platens.

Leather packings—to hold the pressure which lifts the main ram of the molding press in closing. These must be tough enough to stand up under the strain of constant motion, and resistant to heat and pressure. The nature of the packing differs according to the degree of heat being used at the press. Cup or "U" type oak-tanned packings are found to be adequate for lower temperatures, while chrome-tanned packings are more satisfactory where temperature is held at a higher degree.

All this it takes to run the presses, but it is only the

Capable of drilling six, 24-in. deep holes at one time, this machine (9) quickly and efficiently makes channels in molds to accommodate steam for heating and cold water for chilling. The Pratt & Whitney jig-boring machine (10) and Keller mold hobbing machine (11) facilitate the production of dies and speed up the making of duplicate cavities from master designs. (Photos, courtesy General Electric Company)

9



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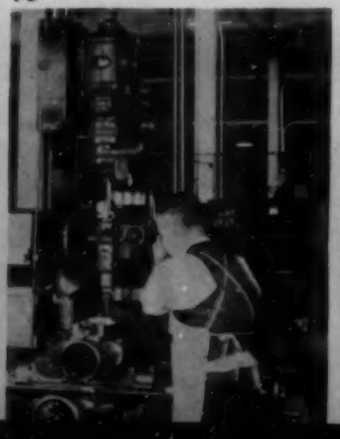

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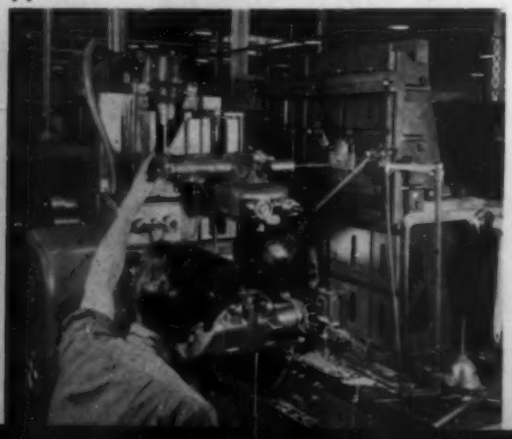
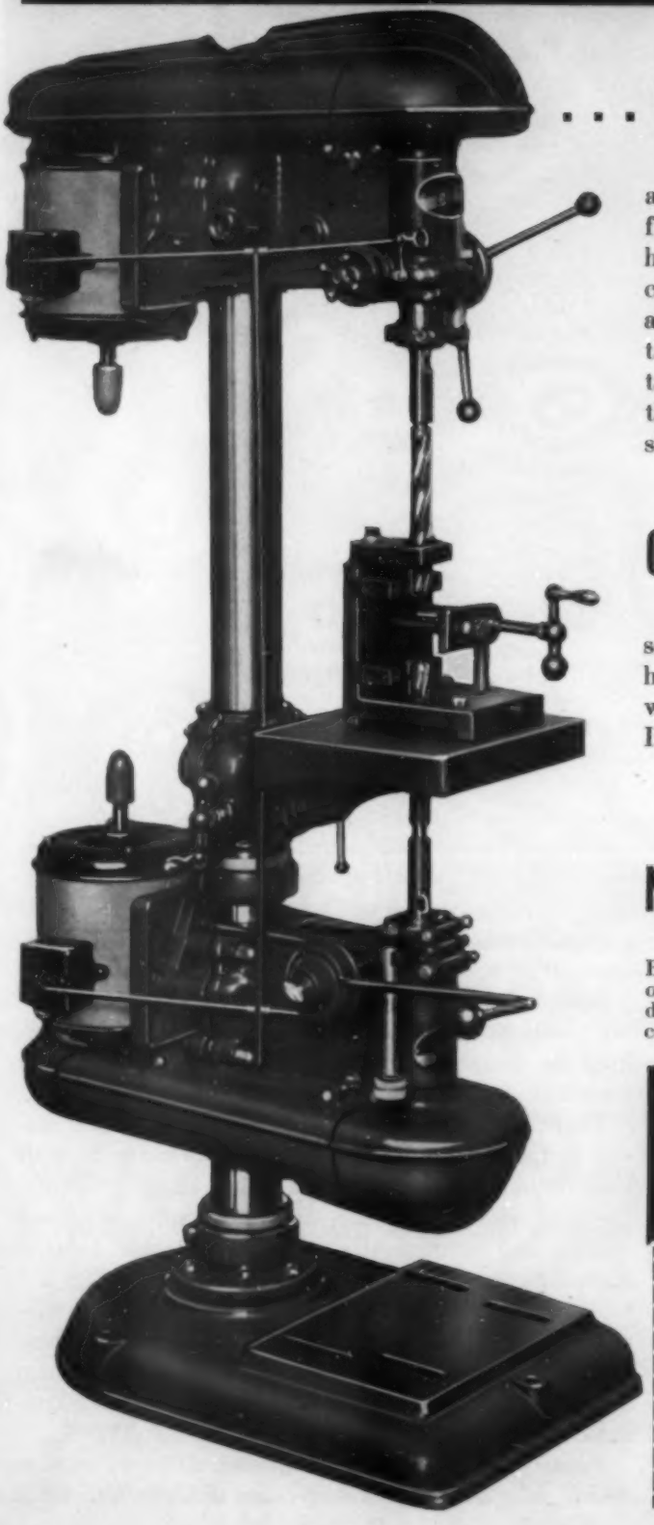


The New Technique for Special Set-ups



. . . for Plastic Manufacturers

Alert production men in plastic plants all over the country are utilizing this new method for building special set-ups at a fraction of former costs. Delta 14" and 17" Drill Press heads can be purchased separately—and assembled in any combination that best fits your needs. They can be used in any position—vertical, horizontal or at any angle—because their self-sealed ball bearing construction eliminates lubrication problems. Their low cost makes them more economical than anything that can be made up in tool rooms or machine shops. It will pay you to investigate.

OTHER LOW-COST TOOLS USED

In addition to drill presses—the low-cost Delta bandsaws, scroll saws and grinders are being utilized in plastic plants to handle many operations economically and efficiently. You will be astonished at how little it costs to tool up with Delta Industrial Power Tools.

Send for this NEW DRILL PRESS BOOK

Mail coupon for latest Delta Drill Press Book. It contains specifications and prices of complete line of Delta Drill Presses—plus details on individual parts from which you can make your own low-cost assemblies.

DELTA MFG. CO.
(INDUSTRIAL DIVISION)
630 E. VIENNA AVE.
MILWAUKEE, WISC.

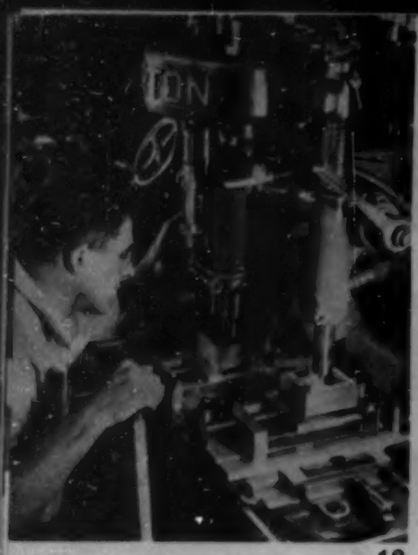
DELTA MFG. CO.
(Industrial Division)
683 E. Vienna Ave., Milwaukee, Wis.

Gentlemen: Please send me a copy of your new 1939 Delta Drill Press Book—also latest information on other low-cost tools suited for plastic plants.

Name.....

Address.....

City.....State.....



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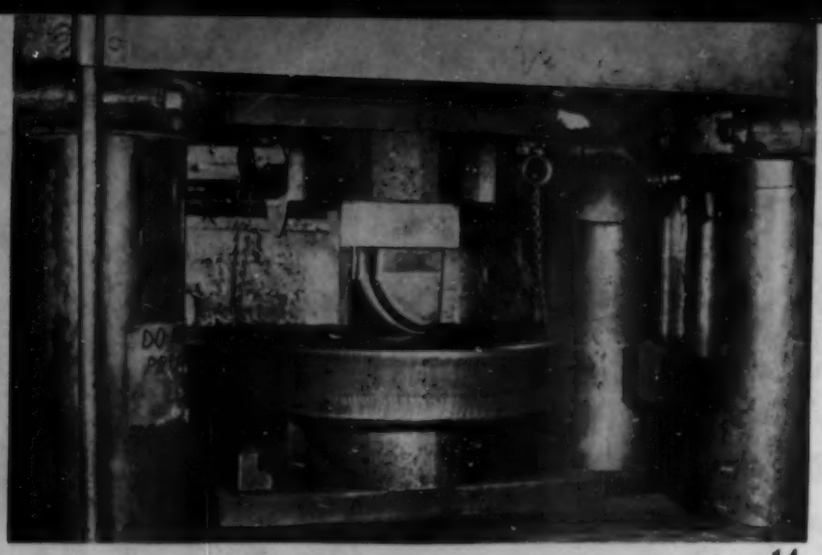

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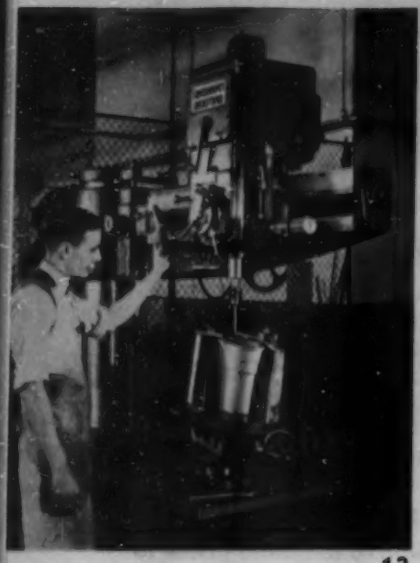

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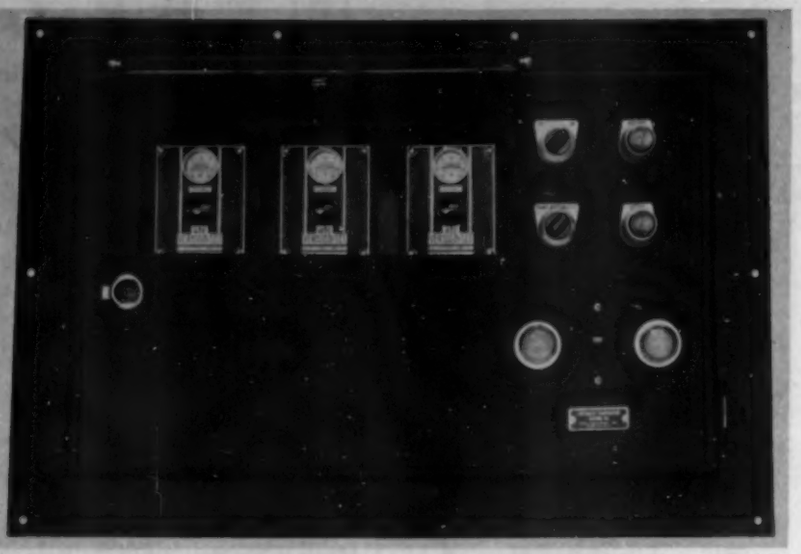

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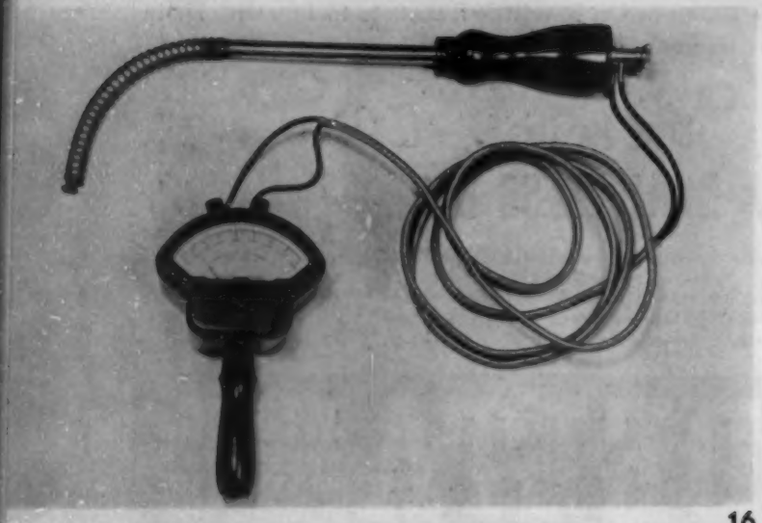

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(12) George Gorton Machine Co. duplicator used in producing molds, punches and dies in tool room of G. E.'s Plastics Dept. Boring holes at an angle (13) is accomplished with a Cincinnati-Bickford radial drill. Fig. 14 shows a hobbing die sinking down into a solid block of steel. (15) Automatic time control panel made by Automatic Temperature Control Co., Inc., to the specifications of Lester Engineering Co. (16) Thwing-Albert surface temperature pyrometer supplied with indicating pyrometer, sensitive contact thermocouple and armored leads for connecting thermocouple to indicator

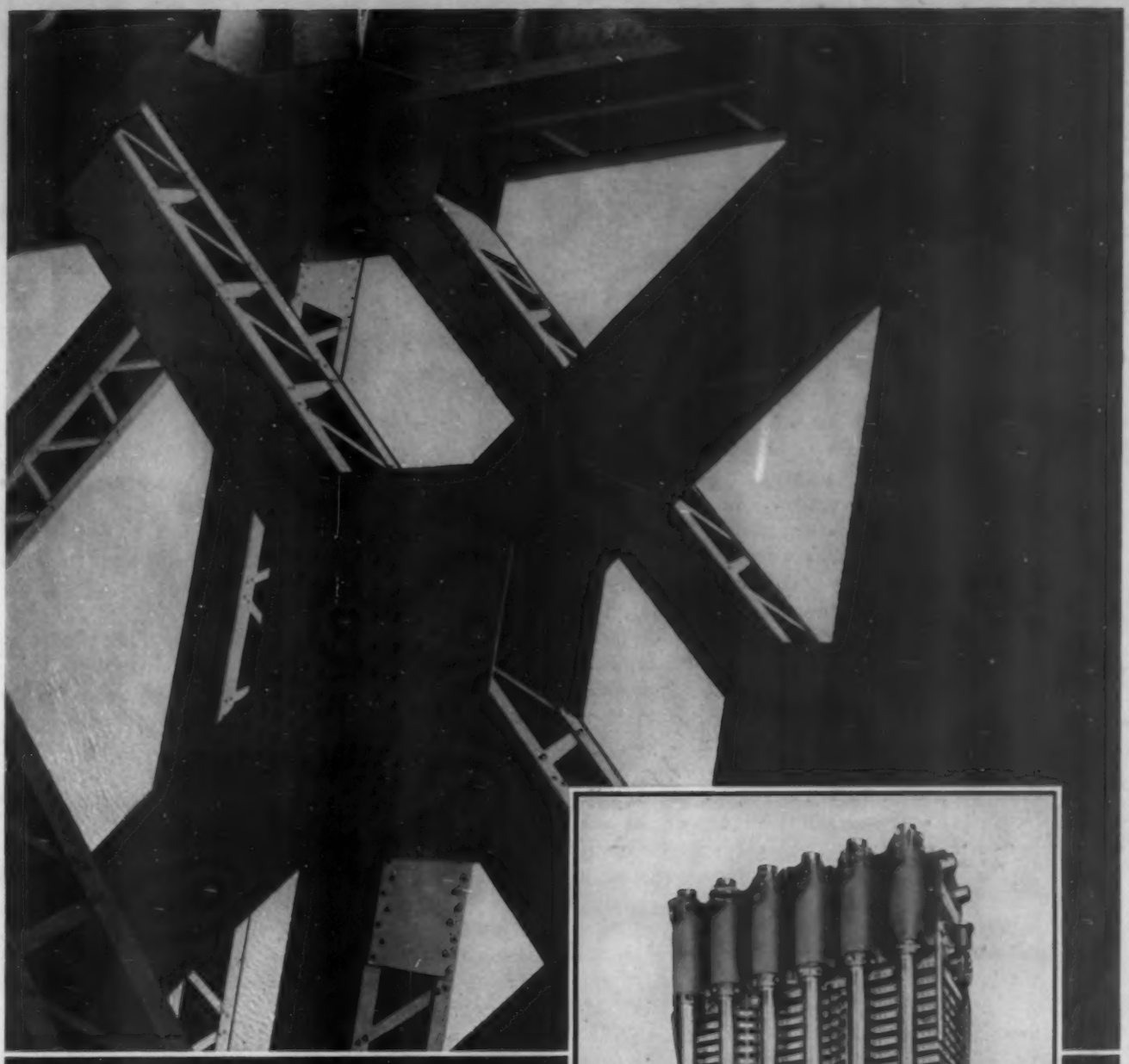
beginning as far as plastics production is concerned.

Tool room. Die making has often been called the "bottle-neck" of the plastics industry. Two or three weeks and sometimes more during rush periods is required to transform a solid block of steel into an efficient, workable mold. The customer, sold on the idea of using plastics for his product, can hardly be blamed for becoming impatient long before the first of his moldings comes from the press. To control such delays as far as possible and speed up the production of dies, many molding plants have invested in a complete drafting department for designing molds and a tool room where the drawings are translated into steel.

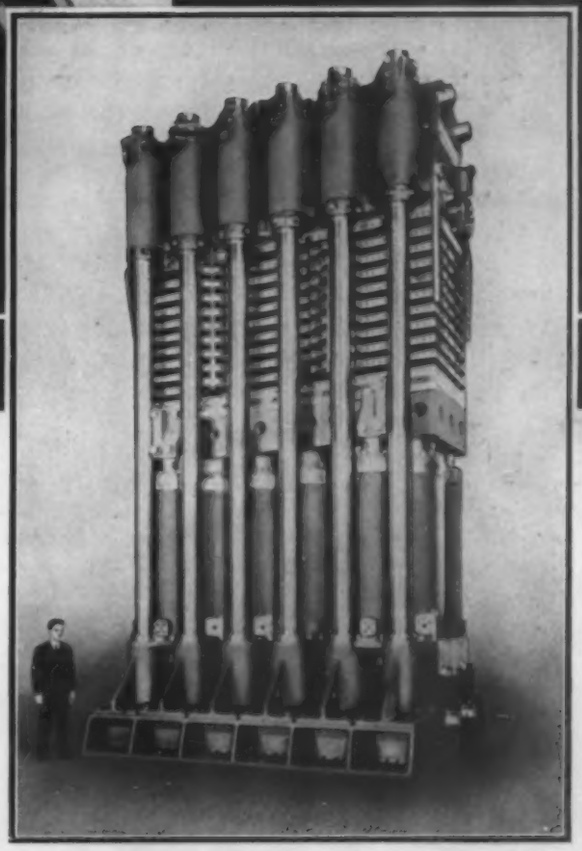
Mechanical saws, planers, shapers, milling and die-sinking machines, grinding wheels, lathes and drills of all sizes are used for cutting, grinding and shaping original cavities. Hobbing presses and duplicating machines quickly and economically reproduce identical cavities from the originals.

Every shop has an assortment of lathes, milling machines, hack saws, surface grinders, tool grinders, punches and drills for repairing molds and keeping them in good working order. It also provides space for convenient storage of idle molds.

Powder storage. Molding compound, delivered in huge drums, must be classified as to color and type and stored



STRENGTH . . .



In R. D. WOOD hydraulic presses, strength is as carefully engineered as in a modern steel bridge. Dependable strength is but one of the many reasons why it will pay you to consult WOOD engineers on your hydraulic press requirements.

R. D. WOOD CO.

PHILADELPHIA • PENNSYLVANIA

HYDRAULIC PRESSES AND VALVES FOR EVERY PURPOSE

in such a manner that it can be used in the same order it comes into the shop. Racks, in tiers, serve in some plants as a convenient method of accomplishing this. Incoming drums of material are hoisted onto the rear end of the proper rack while the drums to be used are rolled off the front end. Sometimes drums of powder are stored in individual bins, with the latest arrivals always at the back. Marking the date on incoming containers is another way of keeping them in the right order.

Air conditioning or at least controlled temperature is important in the powder storage room. There is a certain amount of plasticizer or lubricant in the material when it arrives at the plant. If a drum is partially used and then allowed to remain in a room that is too hot or too dry, some of the plasticizer or lubricant is bound to evaporate and when that compound finally reaches the press, it does not give optimum results.

Preparation of powder for molding. Because, for the majority of applications, loose powder is bulky and difficult to manipulate without a lot of waste in material and time, it has become customary to compress it into pills or tablets. This is done on a preform press of the same type used for tableting aspirin and other pharmaceutical products, with the addition of pressure and larger cavities. Oversize or odd-shaped preforms are produced in nominal quantities on a single punch press, while a rotary press goes into action for consistent production of large quantities of smaller tablets.[3]

Occasionally preform presses are designed and built by the molding plant's machine shop to take care of its own requirements. In one such instance each preformer, placed in a separate air conditioned room, is fed with powder that flows through covered pipes from an original drum of material, enclosed in a metal jacket, on a balcony above and outside the room. The preformer is of the single punch type, capable of compressing 300 pills a minute. It consists of several cavities in a horizontal row with corresponding punches properly spaced above. As the powder loader moves forward, it pushes off the row of pills that pop up from the cavities at the right moment and refills the cavities for the next batch. As it moves backward, the punches descend and press the powder into shape.

Preforms may be large or small, round, oblong or square depending on the size and shape of the piece to be molded. Some shops go in for rather elaborate preforms that closely resemble the actual shape of the finished molding. The tablets are reasonably solid and certainly easier and cleaner to handle than loose powder but they do break and chip at times and if these damaged pills are allowed to enter the mold, imperfect plastic parts are likely to result. That is why one molder has built his own robot molding press, combining an electrically operated preform press and a hydraulic compression press, with the same number of cavities in each. Preforms made and partially cured at one end of the machine, travel across a flat bed and drop into corresponding cavities in the molding press at the other end. Since the pills are used as fast as they are made without being touched by human hands, there is little or no danger of broken or damaged charges, and every ounce of powder is accounted for in a molded piece.

It is common practice to separate preform presses by partitions or booths. This is especially true of those operating on colored materials since the tiniest speck of a different color will show up in the finished molding.

No matter how carefully the preforming job is done, loose powder is bound to fly about now and then. Ordinarily this is disposed of by a dust collecting system with exhaust hoods located at each point where they are likely to be needed.

To avoid as much waste as possible each charge of loose powder, which is still used for certain applications, must be measured as accurately as are the preforms. It may be weighed into suitable containers by hand on an accurate scale, or measured automatically by machine in the pilling room or at each press. In a simple method adopted by one shop, an original drum of molding compound is fitted with a funnel at its dispensing end and suspended between two pipes at each press. The press operator holds his loading board under the funnel, re-

[3] See articles, "Preforming," page 218 and "Preforming Presses," page 374.

Recording thermometers (17) for temperatures from —40 deg. to 1200 deg. F. are supplied by Brown Instrument Co. Wherever hand molds are operated, arbor presses provide a convenient means for separating the parts to remove the molding. The two illustrated are: (18) A Hannifin arbor press equipped with an improved pneumatic cylinder; and (20) a Greenerd 1½-ton, self-contained bench type hydraulic arbor press. Fig. 19 shows a Revolvator that performs all sorts of special duties such as handling dies, drums of molding compound and the like

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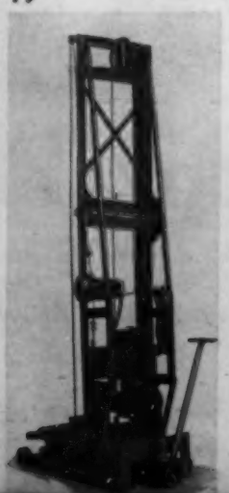

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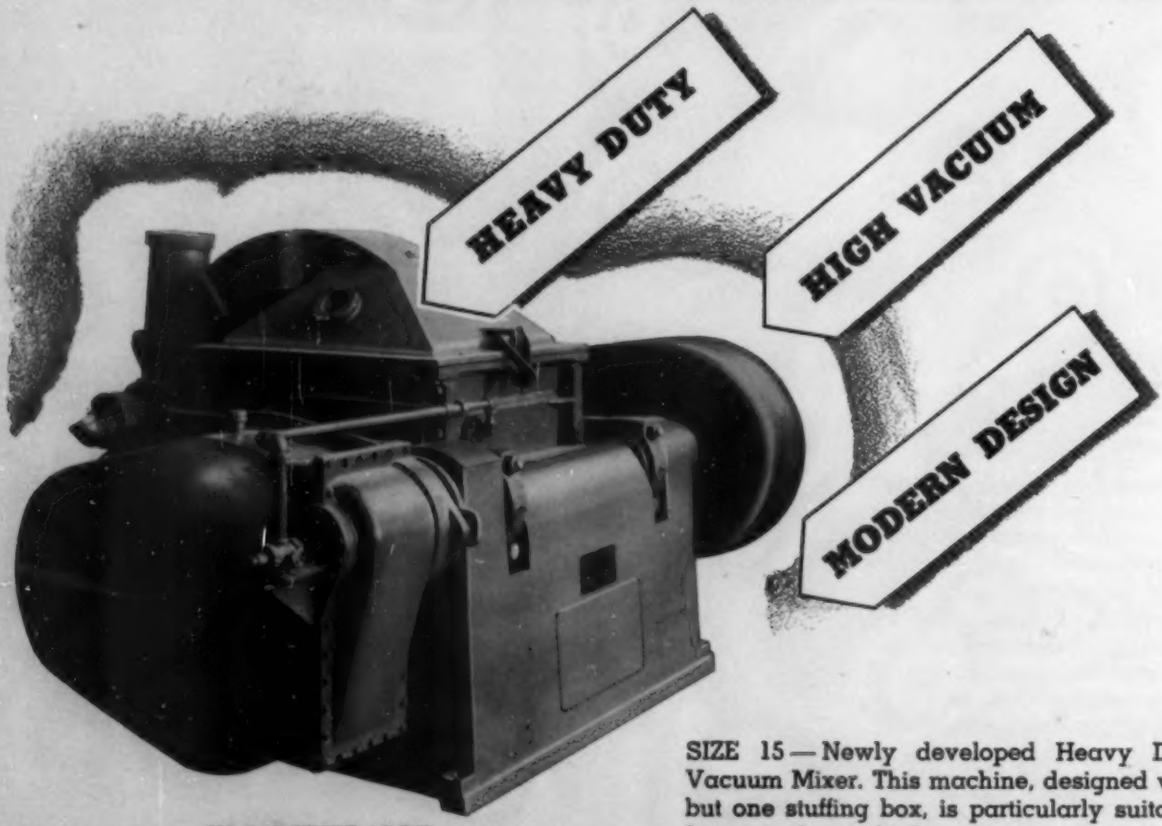

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21

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23

Both 7 and 9 in. abrasive disks may be used on the two-speed sanding unit (21) developed by Van Dorn Electric Tool Co. An all electric sanding, rubbing and polishing machine (22) that may be used on flat, curved or irregular surfaces. Called Easy Electric Sander, it is marketed by Detroit Surfacing Machine Co. Dust and fine particles incident to filing, grinding or sanding operations are removed through an adequate ventilating system in the finishing room at G. E.'s Plastics Department

leases a spring cap, and the powder drops into the cups as he slowly moves the board back and forth to catch it. By this method little powder is lost and no dust can enter the drum of material.

The well-planned preform room also has a small machine for regrinding broken, chipped or otherwise defective pills; sensitive scales for checking the weight of pills from time to time; and convenient storage racks for idle preform dies. Then there must be tote boxes, trucks or conveyors to carry preforms or powder to the various operators in the pressroom.

Accessory pressroom equipment. In developing the molding process, it has been learned that preliminary heating of powder or preforms has very definite advantages. For one thing, it shortens the molding cycle considerably since preheated material is already well on the way toward softening when it is loaded into the die. And the shorter the cycle, the greater the number of pieces turned out by each press during a working day. Then, too, parts molded from preheated material are claimed to be more uniform, better appearing and to have improved dielectric qualities and heat resistance.

The preheating is done in small ovens at each press or in larger ovens that serve two or more presses. Some are fitted with trays for preforms; others heat powder in cups or other containers. Ovens for this purpose are being improved constantly and several new types have been announced during the past year.[4]

For quick, competent filling of cavities, loading boards are designed to fit each mold as it comes along although they all follow the same general pattern. The boards, made of wood or lightweight metal, are built with the same number of depressions as there are cavities in the mold. Preforms spread across the top drop into each hollow; the loader is accurately spaced over the lower die; a sliding plate is removed from the bottom and the preforms drop into place in the mold cavities. Powder loaders, of course, must be made with larger cavities but along similar lines.

Temperature and time are two most important factors in producing molded parts. If the temperature is uneven, if it is too high or too low, defective pieces begin to come out of the mold. They may warp, shrink and discolor, the surface may be rough and blistered and they are of no use to the molder or anyone else. Therefore, once the proper temperature has been determined for the material being run, the mold cavities are checked from time to time to make sure there is no variation in heat. Pyrometers are useful for this purpose and they are available in a variety of styles and sizes.

Manually or electrically operated timing devices, attached to each press, that flash a light or ring a bell when a cycle has been completed are favored by many. These usually operate on 30 sec. to 10 min. periods. A master electric clock, placed so that all can see it, is helpful for timing longer cures.

Each pressman needs a good sized bench or table for the business of preparing his loading board, for his supply of molding material, for metal inserts if they are to be used in the piece he is molding, and for the assortment of tools that he uses on the job, as well as protectors of one sort or another that help prevent his being burned or otherwise injured at his work. Among his tools are hammers, plyers, tweezers and scrapers, along with special gadgets that he may need to unscrew or eject pieces from the mold.

Hand-operated arbor presses are usually installed wherever hand-molds are being used. The hot mold is clamped into the press, separated and the part taken out in a minimum of time.

The press room is not complete unless some provision is made for inserting and removing large, multiple-cavity molds from the presses. Cranes or overhead pulleys may be preferred or an elevator-type truck that raises the molds to the level of the press opening where they are pushed and tugged into place. Placed in a convenient corner in many press rooms, is a de-greaser where all dies are treated before being hoisted into the press, to remove every trace of the oil or grease that has been smeared on to protect their surfaces.

Finishing, inspecting, packing. When the plastic part, whether it is a handle, a bottle cap, a tray, a box or an electrical attachment, comes from the press, there is a

[4] See article "Preheating Ovens," page 380.

certain amount of overflow material or thin flash clinging to it that has to be removed. With small pieces this is best accomplished by rolling them together in a rapidly rotating tumbling barrel until the flash has been broken off. Tumbled for a second period in a barrel containing wooden pegs and wax, the pieces emerge with a satiny smooth, lustrous surface.

Superfluous material is removed from larger pieces by machine grinding on horizontal and vertical belt sanders or by hand filing. Holes for assembly devices or inserts, not always practical to mold into the part, may require high-speed multiple-spindle drill presses and tapping machines. Holes that are molded in are likely to be closed with a thin film of flash which is forced out on a punch press. A session with a buffing wheel, treated with polishing compound, imparts the final finishing touch.[8] Fine particles of dust and dirt incident to grinding, drilling and tapping operations are removed from the finishing room through exhaust hoods connected with the dust collection system.

More and more molders find it to their advantage to have such equipment as roll leaf stamping presses and other devices for marking and inlays, for identifying company products where names or symbols are not engraved in the mold, for inserting trade names and for other decoration and ornamentation. One molder, for instance, has developed a special method of firmly embedding gold stripes on a curved surface. Undoubtedly facilities for metal plating will in time be installed in many plants for lining the interior of cosmetic jars and other containers to make them impervious to moisture.

Molded pieces, large ones especially, receive inspection all during their trip from the mold to the packing room—from press operators, who look them over casually as they come from the die, and finishers, who detect many an imperfection as they handle the parts, to trained inspectors who carefully eliminate moldings that are deficient in any respect. Parts that are to be assembled with others into a finished object and, therefore, must be held to close tolerances, are checked with precision instruments such as micrometers, calipers or block gages built to size for individual jobs.

Small items, such as bottle caps, produced in sizable quantities, ordinarily do not receive minute inspection. Some sort of machine—a hopper that spills the pieces onto a moving belt, for example—may be rigged up in the shop to speed the inspection process.

Packing equipment is about the same as that used in any other shipping department. Small parts may be poured into cartons, the correct number usually being determined by weight, and no further interior packing is necessary. Large pieces are sometimes wrapped or separated by partitions in the carton to avoid any possibility of their being scratched.

The modern molding plant is a properly lighted, well-ventilated unit. Natural daylight is utilized as far as possible, augmented wherever necessary by intensive overhead illumination or individual droplights that can be adjusted to fit the needs of each worker. Excessive heat caused by the operation of presses is removed by electric fans or blower systems.

Although the apparatus mentioned is essential to any capably run plastics molding plant, each shop has an individuality all its own. In custom molding, particularly, because each job has its own peculiarities, its own exclusive requirements, each molder works out his own methods and tools for handling it. With the trend toward electrically operated, self-contained automatic molding presses that have developed so rapidly during the past year, the accessory equipment picture will undoubtedly change to quite an extent. Automatic machinery has a tendency toward eliminating some of the finishing operations and there won't be as much flash to remove or as much buffing and polishing to be done, although small parts probably always will be tumbled and some large parts will have a better appearance if they are polished. However, it is safe to assume that each type of job will still call for special equipment, but it will be along automatic lines.

[8] See article "Finishing Methods and Equipment," page 314.

While flash is removed from small molded pieces by rotating them in a tumbling barrel, larger parts require more individual attention similar in nature to the operations shown below. (24) A molded part is tapped for a screw insert. (25) Flash is removed from a small molding on a motor-driven sander. (26) Plastic pieces are skillfully drilled, tapped and burred by trained operators. (Photos, courtesy General Electric Company)

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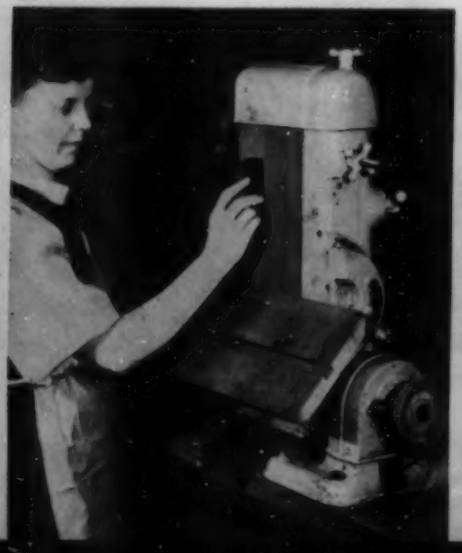

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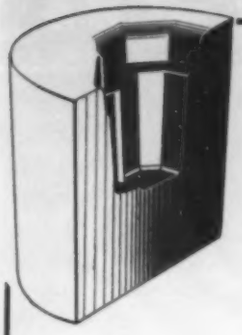
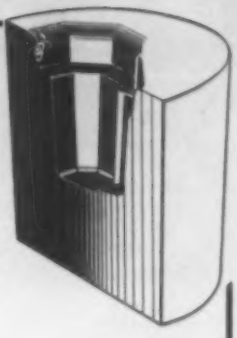


HOBALITE

for

HOBBED MOLD DIES

A GOOD SINKING IN 1935



TODAY

PERFECT CAVITIES ARE HOBBED

12″ x 6″ x 2½″ Deep—10″ Dia. x 3″ Deep

The plastic molding industry grows in leaps and bounds. We had to improve Hobalite at that pace. March 1939, closed a long period of research and checking under actual hobbing conditions, proving we had improved hobability, reduced porosity, and improved reaction to heat treatment.

The hobbed cavities in Hobalite have that perfect finish which gives high lustre to the molded part. Properly case-hardened and heat treated it withstands a pressure of **82 TONS PER SQUARE INCH.**

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This highly alloyed tool steel contains nine outstanding characteristics: Still Air Hardening, Minimum Deformation, High Hardness, Non Scaling, High Compressive Value, High Abrasive Resistance, Heat and Corrosion Resisting, Very High Polish, Grinds Super Keen. Each characteristic is directly applicable to a fine and high productive Plastic Mold Die Cavity.

We help your costs to a moderate total by casting PRK, leaving a minimum of machining, and frequently only a grinding operation for the cavity finish.

HOB STEELS

NEOR HARGUS OR BRAND H DO-IT

Steel for hobs must contain high compressive strength, high hardness, high polish, minimum of change of size and deformation in heat treating.

NEOR and HARGUS Brand H both contain these features, but if pressure develops per inch in the maximum range, namely, 220 tons, NEOR is recommendation No. 1, owing to its deeper hardening, and HARGUS Brand H is No. 2.

When cavities are narrow, long and deep, the above physicals become secondary to a high elastic strength, so in that class of hobs we recommend DO-IT.

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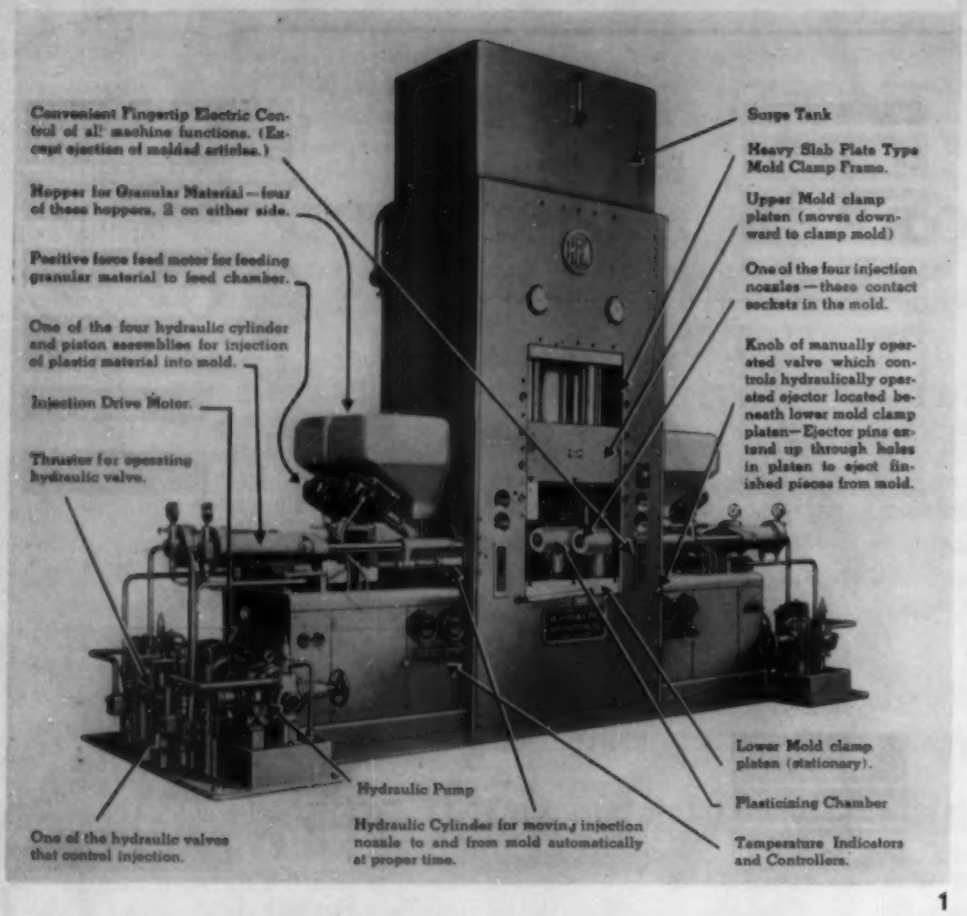

Convenient Fingertip Electric Control of all machine functions. (Except ejection of molded articles.)
Hopper for Granular Material—four of these hoppers, 2 on either side.
Positive force feed motor for feeding granular material to feed chamber.
One of the four hydraulic cylinder and piston assemblies for injection of plastic material into mold.
Injection Drive Motor.
Thruster for operating hydraulic valve.
One of the hydraulic valves that control injection.
Hydraulic Pump
Hydraulic Cylinder for moving injection nozzle to and from mold automatically at proper time.
Surge Tank
Heavy Slab Plate Type Mold Clamp Frame.
Upper Mold clamp platen (moves downward to clamp mold)
One of the four injection nozzles—these contact sockets in the mold.
Knob of manually operated valve which controls hydraulically operated ejector located beneath lower mold clamp platen—Ejector pins extend up through holes in platen to eject finished pieces from mold.
Lower Mold clamp platen (stationary).
Plasticising Chamber
Temperature Indicators and Controllers.

1

This represents the latest development in equipment for injection molding by the multiple-cylinder method. With a clamping capacity of 500 tons, there are 4 injection units each with a plasticizing capacity of 9 oz. per cycle. The features are well pointed out

MULTIPLE-UNIT INJECTION PRESSES

by HOWARD F. MACMILLIN*

SINCE ONE SHORT YEAR AGO, THE PRINCIPLES of multiple-unit injection molding have been firmly established through application to mass production of large thermoplastic products. During this twelve-month interval, machines having double the plastic injection capacity of previous models were placed in regular commercial operation. This increased rating has also been matched by larger die areas and much higher mold clamp pressures.

Nearly a year's regular production operation of these improved, larger multiple-unit injection machines has not only thoroughly substantiated the advantages previously attributed to the type but has brought to light important new benefits. All of these add up to the ultimate point that multiple-injection makes practical the molding of articles having very large areas, mass, and also intricate shapes. Weights expressed in pounds rather than ounces are now commercially practicable.

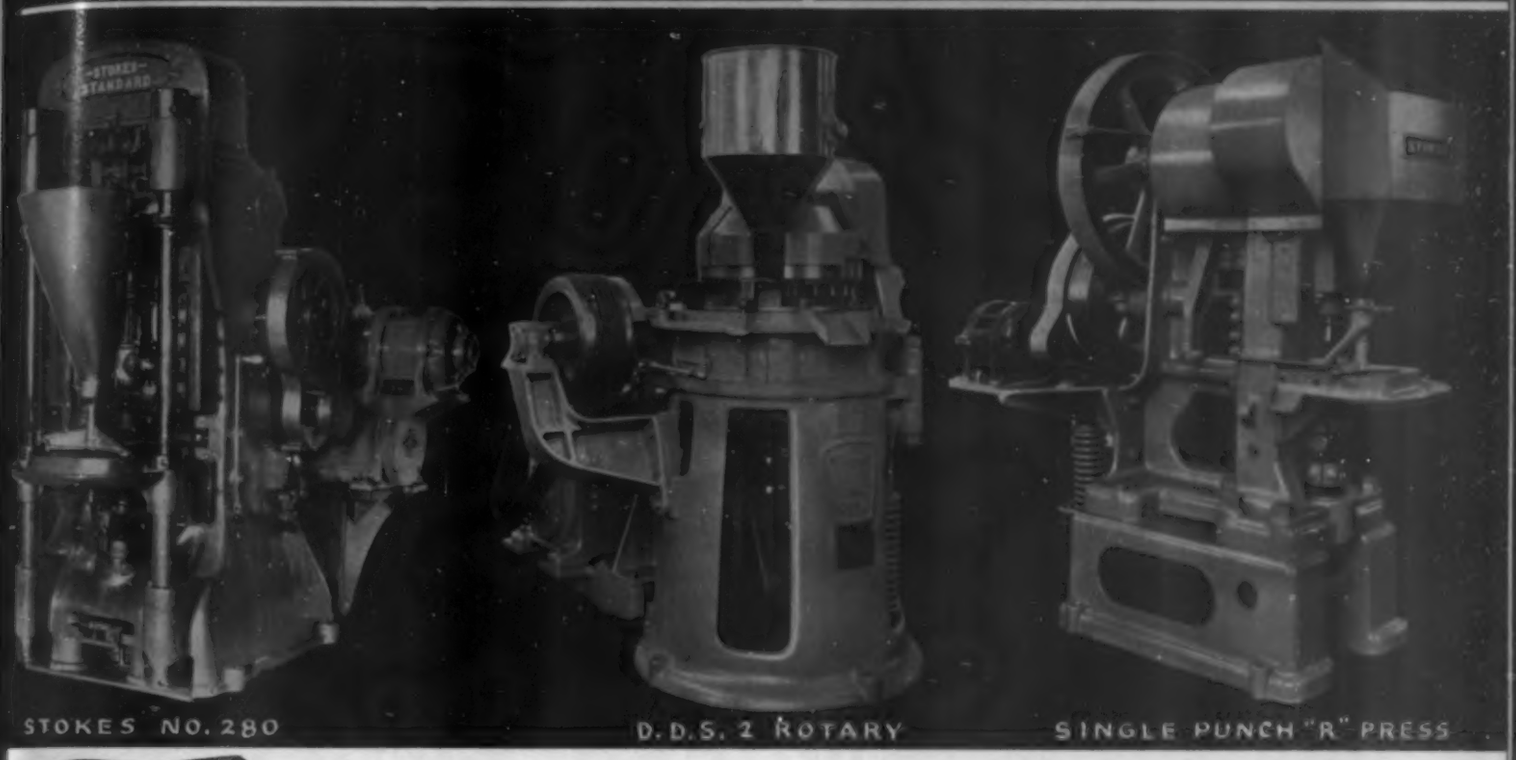
There are a number of reasons for believing that the plasticizing capacity of a single-injection heating chamber is relatively limited. The capacity of the largest single units now on the market are rated by their makers at 8, 9 and 12 ounces, respectively, in terms of thermoplastic injected per cycle. New materials with molding characteristics requiring higher temperatures, increased injection pressures and increased injection speeds place still greater demands on the power capacities of the machine and without increased plastic output. However, regardless of the ultimate limiting capacity of a single unit, practical operation during the past year has shown the need for injecting certain articles from more than one plastic source. This has pertained even in molding parts within the weight limit of existing single-unit heating chambers of injection presses.

As an example of the foregoing is an article of extended area and thin sections. Attempts to mold with a single unit even though gated at several points along one side, result in incomplete filling of the cavity. Injecting with two units from opposite sides provided the solution.

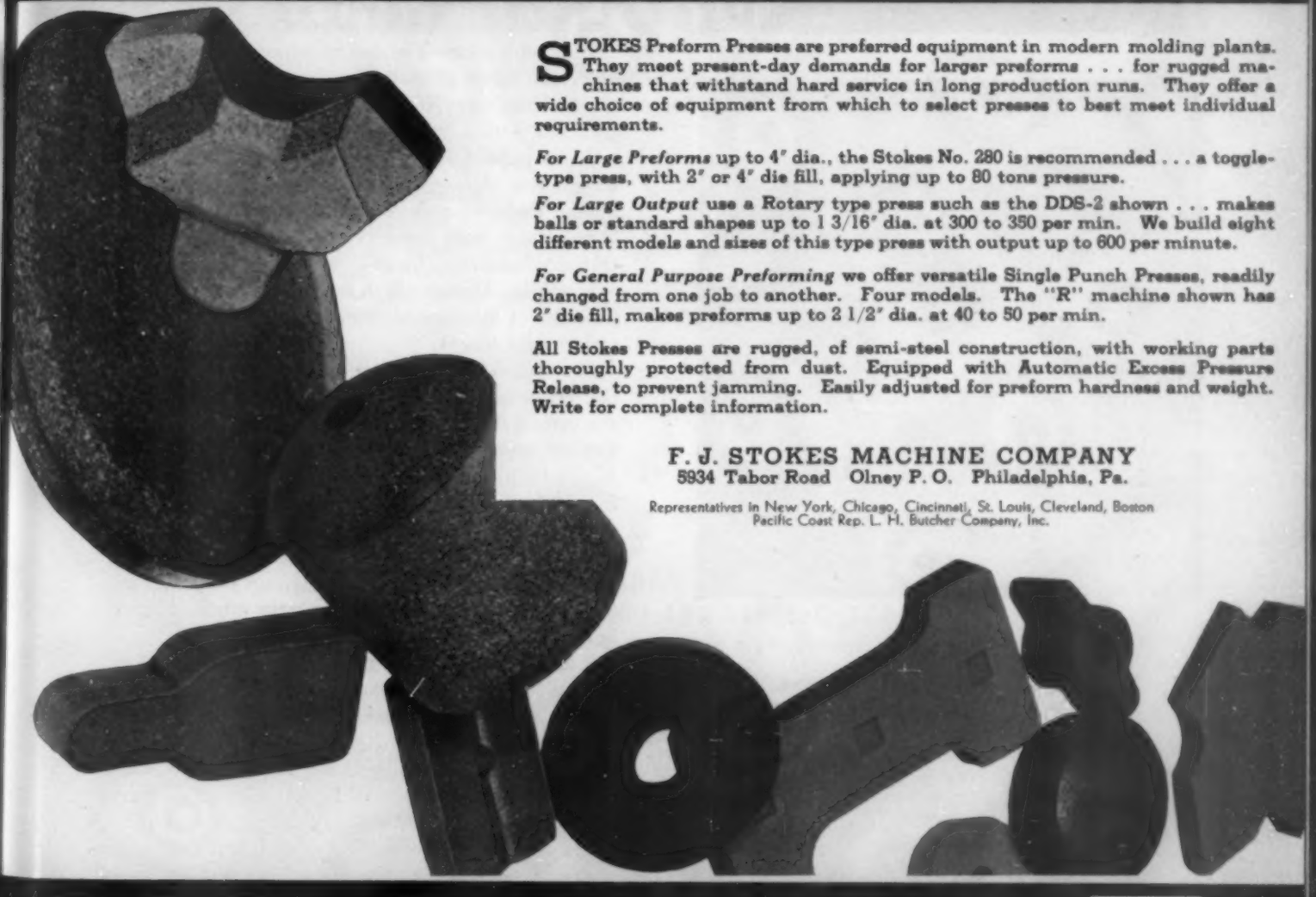
When molding a large piece, the material must divide as it flows into the mold spaces, later to re-unite with a welding of the material taking place. Full strength at the weld and avoidance of weld marks require that the ma-

* Hydraulic Press Manufacturing Co.

PREFORM PRESSES



STOKES NO. 280 D.D.S. 2 ROTARY SINGLE PUNCH "R" PRESS



STOKES Preform Presses are preferred equipment in modern molding plants. They meet present-day demands for larger preforms . . . for rugged machines that withstand hard service in long production runs. They offer a wide choice of equipment from which to select presses to best meet individual requirements.

For Large Preforms **up to 4″ dia., the Stokes No. 280 is recommended . . . a toggle-type press, with 2″ or 4″ die fill, applying up to 80 tons pressure.**

For Large Output **use a Rotary type press such as the DDS-2 shown . . . makes balls or standard shapes up to 1 3/16″ dia. at 300 to 350 per min. We build eight different models and sizes of this type press with output up to 600 per minute.**

For General Purpose Preforming **we offer versatile Single Punch Presses, readily changed from one job to another. Four models. The "R" machine shown has 2″ die fill, makes preforms up to 2 1/2″ dia. at 40 to 50 per min.**

All Stokes Presses are rugged, of semi-steel construction, with working parts thoroughly protected from dust. Equipped with Automatic Excess Pressure Release, to prevent jamming. Easily adjusted for preform hardness and weight. Write for complete information.

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F.J.Stokes MOLDING EQUIPMENT

FJS Est. 1895

terial be entirely plastic at the instant of welding. Naturally, the further the material must flow within the chilled mold the colder and less plastic it becomes before welding can occur. The advantage of decreasing this distance is obvious. Multiple-injection at different points on the periphery of the piece will definitely accomplish that.

In some cases it is found essential to independently control the amount of plastic injected by each unit, providing more from one than another, according to the shape or other characteristics of the piece produced. The use of multiple-injection introduces many new possibilities as yet untouched commercially—as for example—multi-color molding.

Altogether, multiple unit operation extends the use of thermoplastics to many products hitherto made of metal, wood or other materials. Typical is the garnish mold for interior trim of automobile windows. Conventional construction has employed metal sections involving many fabricating and finishing operations. The injection molded product not only simplifies production to the single step, but provides new qualities—including beauty, permanent finish, and a sound-deadening property which is important in auto-body construction.

2

3

A 4-unit injection machine producing garnish moldings for automobile window trim is shown in Fig. 2, while a 2-unit press (Fig. 3) is pictured to show each unit serving a separate mold. These presses, built by Hydraulic Press Mfg. Co., are in service at Thermo-Plastics, Incorporated

The multiple-unit machine

Many of the advantages of multiple-injection molding are found in the perfected design of the machine itself. These are revealed in a consideration of its features.

As with any injection machine, two major functions are performed, namely, clamping the mold halves together and injecting the plasticized material. In the case of the multiple unit machine the mold clamp is a vertical, downward-acting hydraulic platen press. The stationary half of the mold is carried by the lower table or bed. The movable half is attached to the face of the press platen actuated by the direct-acting hydraulic ram. This moving platen is guided by adjustable tapered gibs. Their only function is to provide accurate mating of the two mold halves. None of the weight is imposed on the guides as with a horizontal type of die clamp. Naturally, as molded articles increase in size, mold size and weight will increase tremendously, which in no way is limited with this type of press. Presses of suitable type have already been developed with die space ample to take molds as large, for example, as the entire side of an automobile. If there are limitations in the extent of application of injection molding, it is certainly not in the molding machinery.

The hydraulic system for operating the mold clamp ram provides means for closing the mold quickly, once the cycle has been started. During this rapid-traverse forward movement of the large clamp ram, its cylinder is prefilled with oil (used as the hydraulic operating fluid) from an overhead tank. This oil supply is mounted directly on top of the cylinder. Communication between tank and cylinder is through a special automatic valve built into the cylinder head, not unlike an automobile engine poppet valve but very much larger and heavier than that type valve.

With direct hydraulic ram action, molds of various heights may be accommodated without press adjustments. Any desired pressure within the capacity limits may be applied at any closing position. The pressure required to hold a mold without flashing is determined by gages indicating tons total load. Although the vertical die opening exceeds the maximum ram travel, accidental overstroking without dies in place is made impossible by full tonnage stop rods. *(Please turn to next page)*

SET UP YOUR OWN PRESS REQUIREMENTS

Whatever you specify, Birdsboro can build the Hydraulic Plastic Press that exactly meets your requirements

HERE'S WHY IT'S POSSIBLE . . .

- **30 years' experience** in building every type of hydraulic plastic molding press used in the plastic industry.
- **Large staff** of competent, highly trained hydraulic engineers.
- **Proven ability** to make original and low cost designs to meet specific requirements.
- **Ample facilities** to design and build under *one* roof and *one* responsibility the complete press and its controls.
- **Our own foundry** where all cast parts are PRECISION CAST by Birdsboro's Randupson Process of Precision Casting.
- **Our own machine shop** completely equipped with the latest high precision machine tools.
- **Trained installation engineers** to help you set up the press and instruct your workmen in its economical use.
- **On Time Delivery.**

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BIRDSBORO *Hydraulic Presses*

HYDRAULIC MACHINERY
STEEL AND CHILL ROLLS • STEEL CASTINGS • STEEL MILL EQUIPMENT
SPECIAL MACHINERY • CRUSHING MACHINERY

As soon as the molds are closed, clamp pressure is built up by a radial-type oil pressure pump, which delivers directly to the clamp cylinder. This radial pump and its direct-coupled driving motor are mounted on the head of the clamp press frame. The pump is a variable delivery, multiple-piston type. The hydraulic clamping force is positive and continuous, the hydraulic power of the pump being applied at the rate of 100 impulses per second, a frequency more than 50 percent higher than that of standard alternating electric current.

The clamping pressure is subject to accurate regulation according to the requirements of each particular mold. This involves merely one simple hydraulic control setting—no fussy mechanical adjustments of die clearances, etc. This control acts on the variable stroke mechanism of the pump itself. It embodies a spring of adjustable compression, tending to maintain the pump on full stroke and a hydraulic plunger acting in opposition. The pump output pressure applied to this plunger will compress the spring and move the pump toward neutral. The pressure required to do this is governed by the setting of the spring. While the molds are held closed the pump is consuming very little power, delivering the required pressure but at practically zero volume.

The injection unit

Each injection unit is a complete self-contained mechanism, with facilities for: (a) Feeding the material of original granular form in properly proportioned amounts; (b) Heating the material to plasticity; (c) Injecting molten plastic into cavities of the closed chilled mold.

A supply of the material is contained in a closed hopper from which a worm-feed screw conveys it into a first section of the injection chamber. This section is cooled by water circulating in a jacket to prevent the material from prematurely heating and sticking. The feed screw is driven by an electric torque motor through an enclosed gear train. The amount of material fed is harmonized with the machine's plastic consumption. This is accomplished by regulation of the number of revolutions of the torque motor per operation together with its frequency of operation.

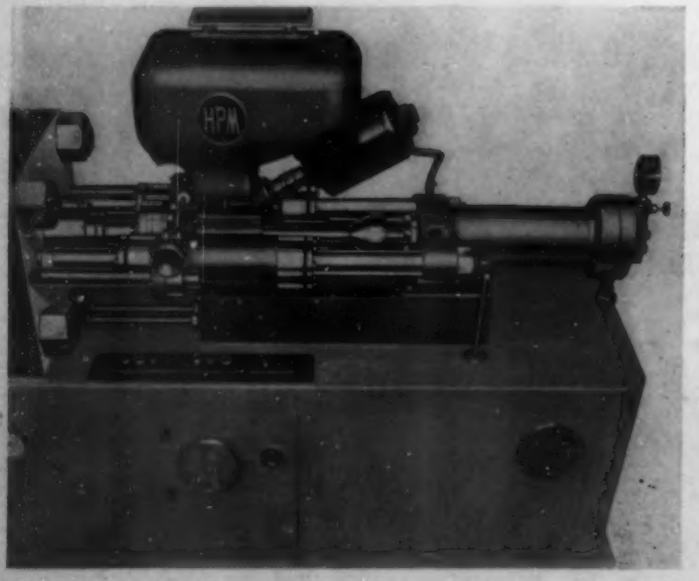
From the feed chamber the material is forced by a plunger into the adjacent heated injection chamber, the passage through them being a continuous one.

The material is heated progressively as forced through the chamber, quickly becoming plastic. For most effective heat transfer, the material is spread out in an annular passage formed by the outer wall of the chamber and a central core. Approach to the outlet nozzle is via a series of converging holes which further aid final heating.

The plunger which forces the material through is actuated by a double-acting hydraulic piston, reciprocating in a smooth bore cylinder. This piston is operated by a hydraulic oil pressure of 2000 lbs. per sq. in., maximum. With a 10 to 1 ratio of piston to plunger areas (and a corresponding multiplication of unit pressures) an injection pressure of 20,000 lbs. per sq. in., maximum, is developed. Still higher injection pressures may be provided for plastics that require it, by construction of the injection unit with a greater piston/plunger area ratio. (*Please turn to next page*)

Fig. 4 shows a close-up view of a standardized injection unit applied singly to a press with horizontal active clamp. This is the same unit that is applied in multiple to the large vertical clamp presses. Fig. 5 is an end view of a typical multi-unit press showing its operating system

4



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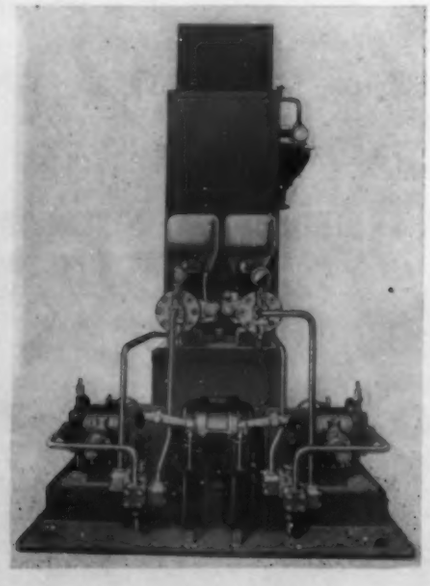

Superheated Water *replacing* Steam *for heating press molds!*

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An installation in a prominent plastics plant less than 2 years ago was described in POWER as "a revolution in process heat." In that short time one after another plastics plant has adopted this simple, efficient method for using hot water instead of steam for heating press molds. High pressure hot water heating provides definite advantages. Write for copy of our Bulletin No. 20 that fully explains these advantages. No obligation.

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6

7

Fig. 6 shows two of the multiple injection presses installed in the plastics division of Firestone Rubber and Metal Products Co. Fig. 7 pictures one of a group of four presses turning out instrument panels and glove compartment doors for automobile manufacturers

Each of the injection nozzles contact the mold along its edges and center on the parting line, which in this case, is in the horizontal plane. The gates are entirely open on the face of the lower mold, hence are particularly accessible for easy cleaning.

The nozzles are held in positive contact with their mold inlets by hydraulic pressure from a pair of auxiliary hydraulic pistons. These are double-acting, and engage the entire injection unit, traversing it to and from the mold along its tension rods. At the end of the cycle each unit moves back, slightly withdrawing its nozzle from contact with the mold, thus breaking off the sprue. The unit-traversing pistons have a much greater total stroke than is employed for normal cycle movement. This can be utilized to entirely withdraw a unit to obtain complete accessibility in servicing.

Each injection unit is a completely independent mechanism with its own individual source of hydraulic power. This consists of a variable delivery radial plunger pump with automatic stroke-regulating pressure control. Both pump and control are identical in type to that which serves the clamp press (as previously described) but of greater displacement. The pump output passes through a balanced piston valve which controls the action of the injection piston. The complete injection units are grouped in pairs at either side of the clamp press. They are joined with the press frame through their tension rods connecting into heavy steel yokes at the frame end.

Within the pedestal supporting each pair of units are two complete heating and circulating systems for the fluid employed in heating the injection chambers. The fluid is heated by electric immersion elements of special characteristics for the service. The temperature is accurately controlled by automatic thermostat-actuated switches. The hydraulic power units for the injection units are also arranged in pairs at the extreme ends, with a double-end shaft motor driving two radial pumps.

All functions of the entire machine are automatically controlled and in timed and coordinated sequence to properly carry out the entire injection molding operation. This is all accomplished electrically, through electric operators for the hydraulic valves controlling the die clamp and each injection unit, together with the individual motors driving the material feeds of the injection units. The operator's control is through panels of electric push-buttons and selector switches. In addition to the press action controls, all of the manual controls for driving motors, and the electric heating and circulating system are centralized at the operator's position. Any of the four injection units may be cut out of service whenever required.

Regular operation is on a semi-automatic basis, started by push-buttons and continuing automatically through every step until completion with the opening of the mold and ejection of finished product. The clamp press ram may be controlled independently in its movements by a hand lever. This is particularly convenient for the initial setting of the die.

That the art of injection molding has been greatly extended through this practical development of the multiple-injection unit system is now certain. Furthermore, it is clear that there is no conflict of single versus multiple injection. Both have their place in the industry. Whatever improvements the future brings in the individual mechanism, whatever its ultimate plasticizing capacity may become, all of the advantages of the single-unit may be extended by the operation of such units in multiple.

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Illustration left. A recent cabinet type plastic molding press. Right. Air ballasted pistonless type, hydraulic accumulator, 275 gallon capacity at 2500 pounds working pressure.

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PREFORMING PRESSES

by CHARLES BOSS and LEWIS W. HULL*

WHY PREFORM? WHAT ARE THE ADVANTAGES, if any, of compressing molding powders into balls, *pills* or shaped forms prior to the actual molding operation? Are the advantages gained sufficient to offset the investment in a preform press and the power and labor required to operate it? These and many similar questions are asked frequently by manufacturers who contemplate the use of plastics or the manufacture of moldings.

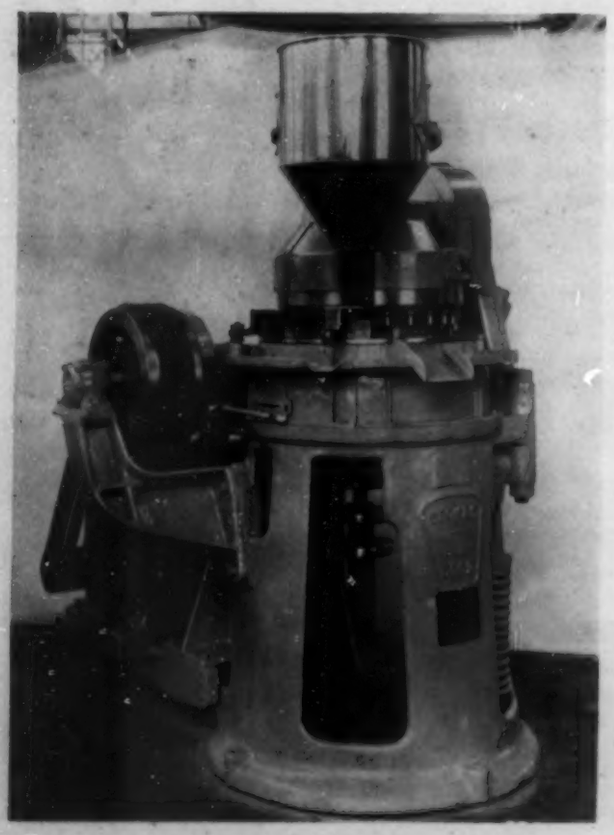
Preforming consists simply of compressing molding powder into tablets or *pills* of various size or into shapes which conform more or less to the form of the part to be molded. These preforms are made in automatic presses developed especially for the purpose, may be used immediately or are readily stored for future use, are of predetermined weight and density as well as form, and their use in the production of plastic moldings is highly advantageous in many operations.

Preforms have many advantages

In the first place preforms are accurate in weight, the volume of powder in each being controlled automatically by the preforming press. Thus flash losses or molding material wasted by overloading the mold cavities in the molding press are better controlled and considerable savings in material are effected. Preforms are cleaner and much more convenient to handle and load into the molding press than loose powder in the conventional loading board. Some material wastage is thus prevented at the loading point.

*F. J. Stokes Machine Co.

Each minute, 350 preforms can be turned out by this Stokes rotary preforming press. Keeping the hopper filled and removing drums into which preforms fall is the only attention it requires in operation



Speeds up molding operations

Preforming offers greater advantages, however, in speeding up production of the molding press on many classes of work and in improving the physical properties of the moldings produced, particularly those of intricate shape in which the material is more uniformly distributed when a properly shaped preform is used. Preforms are dense, therefore, the material plasticizes more rapidly than when in loose powder form. Flow is quicker. Cure is faster. The press is capable of a greater number of heats per hour. And frequently a mold with a lesser number of cavities will produce moldings in the required volume . . . which, of course, reduces initial mold cost.

Another reason why greater output per press is possible when preforms are used is because the mold requires less depth, the powder already having been reduced to about half its original bulk, therefore there is less movement of the ram in opening and closing.

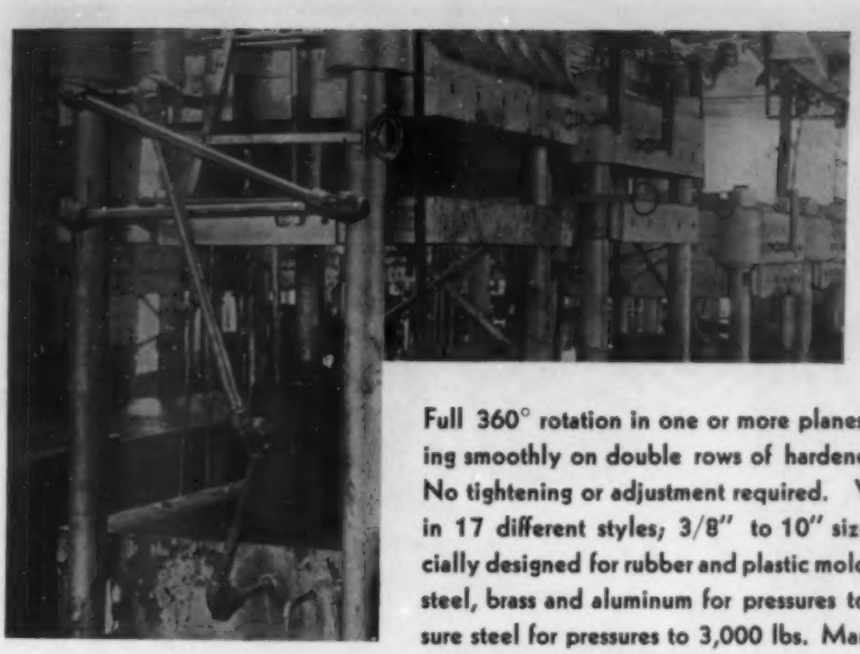
Molds cost less

Worthwhile savings in mold cost result from the use of preforms. As mentioned above the mold has less depth, which means it requires less steel in the making and less high-priced toolmakers' labor to machine, engrave, polish, etc. Thus mold construction is actually cheaper and, because press output is speeded up, as previously explained, it is often possible to effect further savings by using molds with fewer cavities.

It should be understood that the advantages and economies of preforms as outlined above do not apply in every case. While in some instances it is most economical to use large, shaped preforms and in others a number of smaller ball preforms would do an entirely satisfactory job at lower preforming cost, so also is it economical, in some operations, to load loose powder directly into the molds. In general, however, preforms are now being used in increasing quantities, for an increasing variety of work, in larger sizes and in more intricate forms than in the past.

Preheating reduces curing time

The trend toward larger preforms is a natural result of the increasing demand for larger moldings. Presses now



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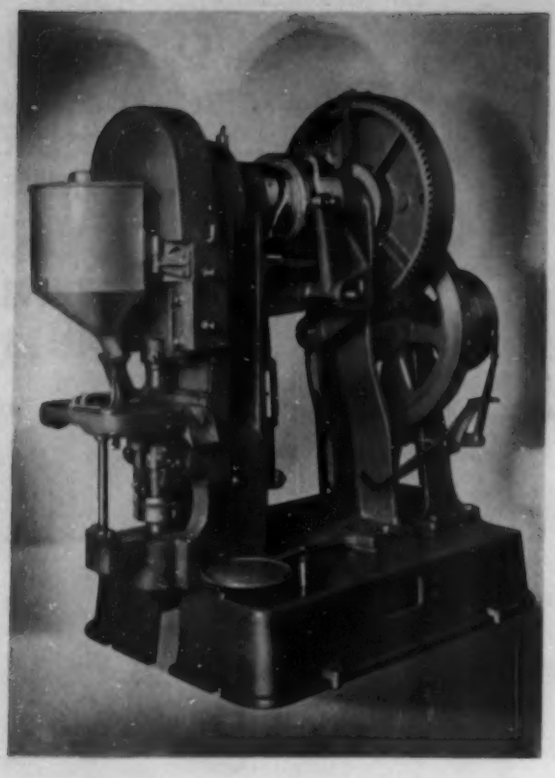
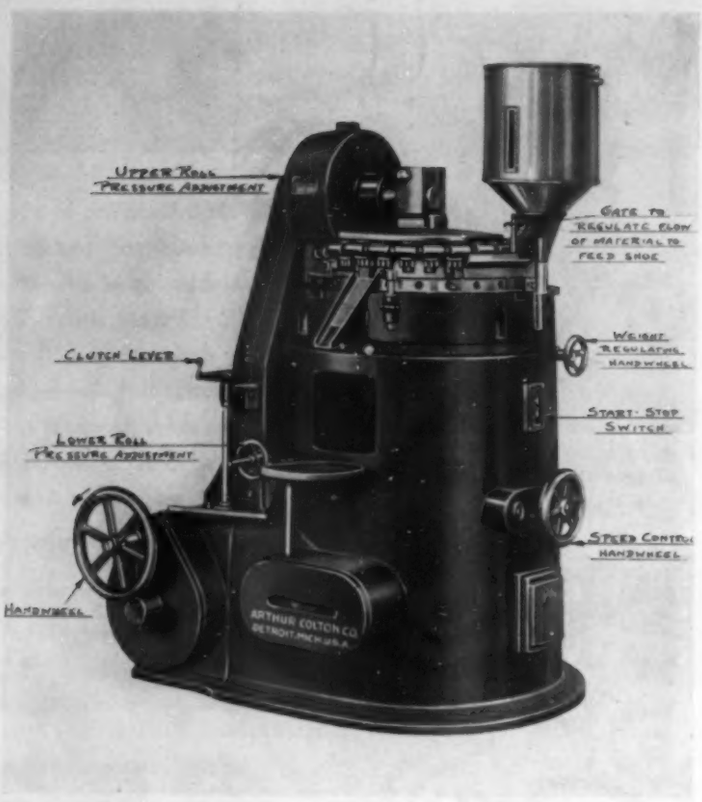


For preforming large size pills and forms, a single-punch type press is generally used. The one above is made by Arthur Colton Company

This is one of the latest rotary tablet machines turned out by Arthur Colton Co. (below). Guide lines indicate the various operating parts



on the market (see illustration on page 378) are making preforms up to 4 in. diameter and 2 in. thick under pressures up to 80 tons per square inch. Another factor that tends to increase the use of preforms for a greater variety of work is the ever-present desire to reduce molding costs. One effective means to accomplish this purpose is to preheat the preforms before they are placed in the mold, thus further reducing the time required for plasticizing and speeding up press operation and output. Preheating is readily accomplished in ovens or on hot plates. It helps lower labor costs, reduces the length of time the press and mold are used to produce the required volume of parts, and in some instances makes it possible to use smaller presses and molds with a smaller number of cavities.

Ball preform advantageous

The ball preform is ideal for preheating. It is easily rolled through a heated tube and loaded into the hot mold and it has the decided advantage, when used in multiple, of crushing to powder in the press, so that there is no dividing line to show where the several preforms flowed together. It is cheaply made with round dies and inexpensive punches. And in making certain types of moldings a number of these inexpensive small balls can be satisfactorily substituted for a single large ball or shaped preform.

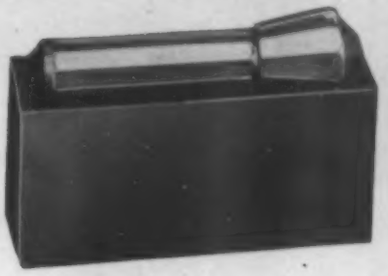
Shaped preforms necessary sometimes

Shaped preforms, notwithstanding the added cost of the die sets required to produce them, are economical in many cases and a necessity in some. The various shapes that can be made sometimes turn an impractical or impossible molding job into a routine operation. The material plasticizes and flows more readily in the mold when the preform shape conforms to that of the molded piece. This in turn insures faster and more uniform cure and, because of better distribution of material, tends to prevent the formation of hidden blisters and improper or insufficient curing which would affect the physical properties of the molding.

Two types of preform presses

There are two distinct types of presses for preforming work; single-punch presses and rotary-type presses which carry a number of pairs of punches and dies and

HOBS
HOBBED MOLD CAVITIES
FINISHED MOLD CAVITIES
AND FORCES



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Accurately produced with shrinkage allowances. High polished finish assures satisfactory finish in cavities. Proper heat treatment produces accurate size cavities.

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Unexcelled high polished finish assured. Cavities are furnished in rough outside dimensions or finished to size.

FINISHED CAVITIES

Machined hardened and polished, ready for your complete mold assembly. Prompt attention given all inquiries for hobs, cavities, forces, or complete molds.

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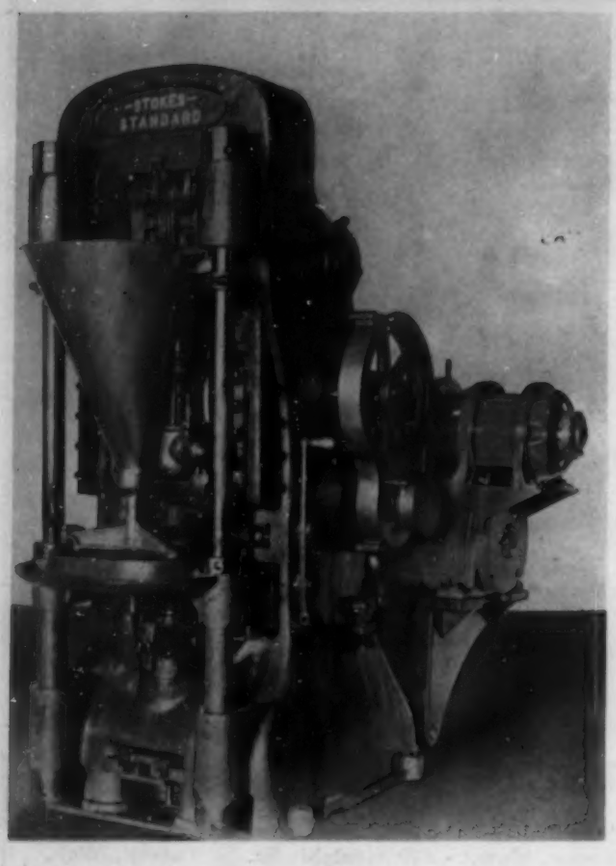


Here is a heavy duty preform press made by the F. J. Stokes Machine Co. It is toggle-operated and is capable of making preforms up to 4 in. in diameter and 2 in. thick. It applies 80 tons pressure to the molding compound

have considerably higher production. The single-punch type is satisfactory for general work where production is limited or where a number of special shapes or large-size pieces are involved. Rotary presses are primarily production machines for making preforms at 200 to 600 per minute. However, they are being used economically on limited production by operating the press with as few pairs of punches and dies as the job requires. Thus the die cost, a factor to be considered, is kept down, while retaining the advantages of greater speed and reserve capacity.

The choice of a preforming press depends upon the maximum diameter or the diagonal of the piece to be made, its thickness or weight and the production desired. In other words, the larger the preform, the larger and more expensive must be the preforming press to produce it.

Presses built especially for preforming

Presses now on the market were developed especially for preforming purposes. They are rugged, fast and powerful, with safety mechanisms to prevent overloading and jamming. They are built to withstand the hard usage of unskilled or semi-skilled operation for three shifts per day and to insure an uninterrupted flow of work from the preforming department.

The demand for harder preforms and operation of machines at maximum pressures has been met by manufacturers with continuous improvements in design and construction. Various devices have been developed to overcome overloading which might cause the press to jam. One manufacturer has developed an automatic excess pressure release, built into each machine, that absorbs and spills the overload without disrupting production. This device can be adjusted to meet varying pressure conditions while the press is in operation, and will even prevent jamming or stalling on centers should a portion of a previously made preform or some foreign substance in the molding powder be charged into the preform die.

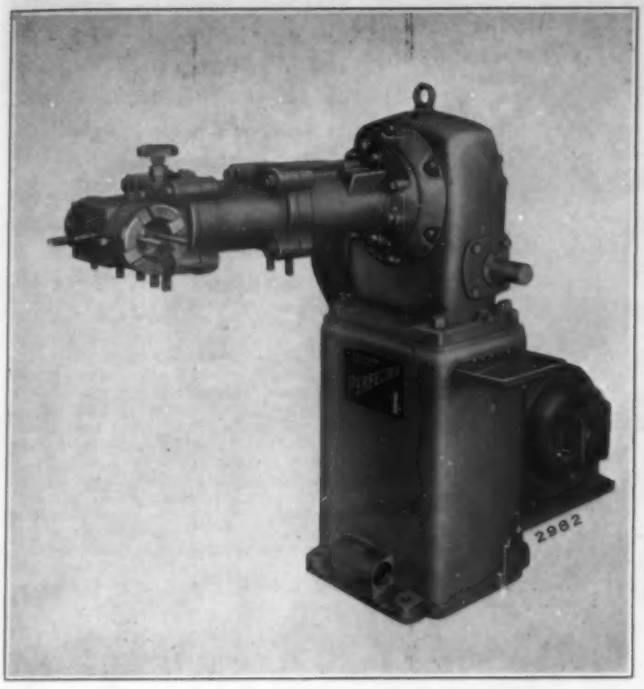
Variable speed drive

Variable speed drive soon pays for itself by increasing production on certain sizes of preforms or with different molding compounds. Some molding compounds also have a tendency to laminate because of the air trapped in them, and a slower pressure or longer *dwell* helps make preforms which otherwise would be impossible. A *Speed Change* is most helpful in such circumstances in that it permits maximum production rather than a lower fixed production which must take care of all conditions. It also frequently enables a machine to *pill* materials which otherwise could not be handled.

Care of punches and dies

Proper care of punches and dies is important to successful preforming. Molders who are strong advocates of preforming all emphasize this fact. Worn dies should be corrected so that preforms are ejected without having to pass through narrower diameters than those in which they were formed. The clearance of the lower punch and the design of the relief used in it are important. This relief should be of the sharp-shouldered type made by undercutting on a lathe rather than by grinding the finished punch. Clearance of the upper punch in the die and clearance between the lower punch and the die should always be sufficient to permit air to escape. This is particularly true when urea compounds are used or large preforms are made, otherwise the trapped air will cause laminations in the preforms and necessitate running the press at a low production rate. Shaker shoes, on single-punch presses, should have perfect bearing on the table to insure both proper die loading and prevent excessive spill over the side of the table. Punches should be inspected at intervals and any roughness on the edges should be smoothed down.

With few precautions, and remembering always that unnecessarily hard preforms, inadequate or improper oiling and greasing and incorrect clearance and relief on punches will all tend to cause needless production delays and repair expense, the user of preform presses should get satisfactory, economical service from his machines for many years of hard, continuous operation.



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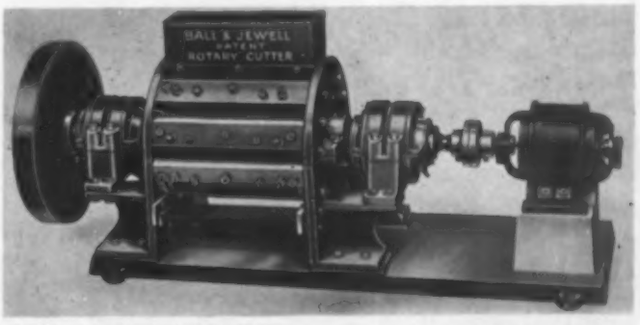

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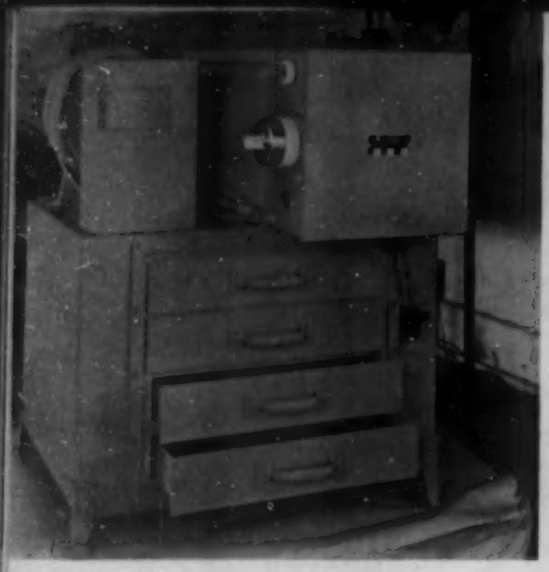

Preheating ovens, until recently, have been mostly home-made affairs. The two at the left, however, were made by Despatch Oven Co. The unit at the extreme left has four trays, 18 in. by 21 in. by 3 in., is equipped with electric heat and automatic control. The upright unit illustrated at the right has electric heat with horizontal air-flow circulation. There are six heating compartments 12 in. by 12 in. by 3 in. with flap doors

PREHEATING OVENS

by E. E. WOODMAN*

THE PRINCIPAL CONCERN OF THE HEAD OF every molding plant is to increase the efficiency of his presses by molding more heats per hour per press. One method of achieving increased production from a die is to decrease the cure time. This may be done by supplying some of the heat required for the chemical reaction of the molding compound before the material is placed in the die.

This preheating of material may be done on the powder but it usually requires special ovens, and even then some trouble is encountered with the fines sticking to the side of the containers. As the powder is filled with countless tiny air cells, it takes a much longer time to secure a uniform temperature throughout the charge. If very fast-curing material is used, there is danger of advancing part of the material to a point at which the plastic will not mold satisfactorily.

Preforms, on the other hand, will heat throughout in a fairly short time and have the additional advantages of uniform weight, ease of loading, and less entrapped air, so they are used in the majority of cases.

When plastic material at room temperature is charged in a mold, the powder next to the die surface is heated and melted while the material on the interior of the charge is still cold. The next layer is then melted until by progressive stages all of the material becomes plastic. This means that when the die is closed, and the closing is likely to be quite slow, the plastic ranges all the way from a set-up condition to a state where it has just become molten. This uneven heating and curing causes flow lines in the part which give a poor finish. It also sets up internal physical strains which cause subsequent mechanical failure when the part is subjected to stress. If cold preforms are used, the first application of pressure is concentrated by the cold pill before it is heated and begins to flow, and in some large parts which require high-tonnage pressure, the stress is sufficient to cause local rupture of the die surface. If heated preforms are used, the material begins to flow as soon as pressure is applied and the movement of the plastic throughout the die is uniform. The die will not be subject to localized strains; the part will have a good finish, and will contain a minimum of internal stresses.

With the use of preheated material the closing time of the die is markedly shortened so that it is possible to use a stiffer material. This is a factor on large radio cabinets or like parts where the use of cold material would require an extra-soft plastic at an increased price. Thus we have a small saving in closing time which, added to the shorter cure—the cure on some jobs may be cut 50 percent—may mean the difference between a profitable job or one which must be run at a loss.

It sometimes happens that after a job is in production it is found necessary to use an extra-strength material, which in general requires a longer cure. By preheating the extra-strength material it is sometimes possible to run the part on the same cycle as a standard type plastic which is not preheated.

It has often been found that high dielectric materials which test satisfactorily when first made will not be satisfactory when molded in the field. This drop in electrical breakdown is due entirely to moisture absorption of the material while in storage and in the preforming and press room before molding.

The moisture content of molding compounds has a great bearing on the plasticity of the material. Materials which have been in storage for long periods or which have been exposed to a humid atmosphere will be slower curing and so soft that they sometimes escape from the mold without creating sufficient back pressure to properly fill the part. If the absorbed moisture is driven off by oven treatment, the material returns to its original plasticity and speed of cure. (*Please turn to next page*)

* Durez Plastics and Chemicals, Inc.

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Bakelite Preforming Machine at the World's Fair

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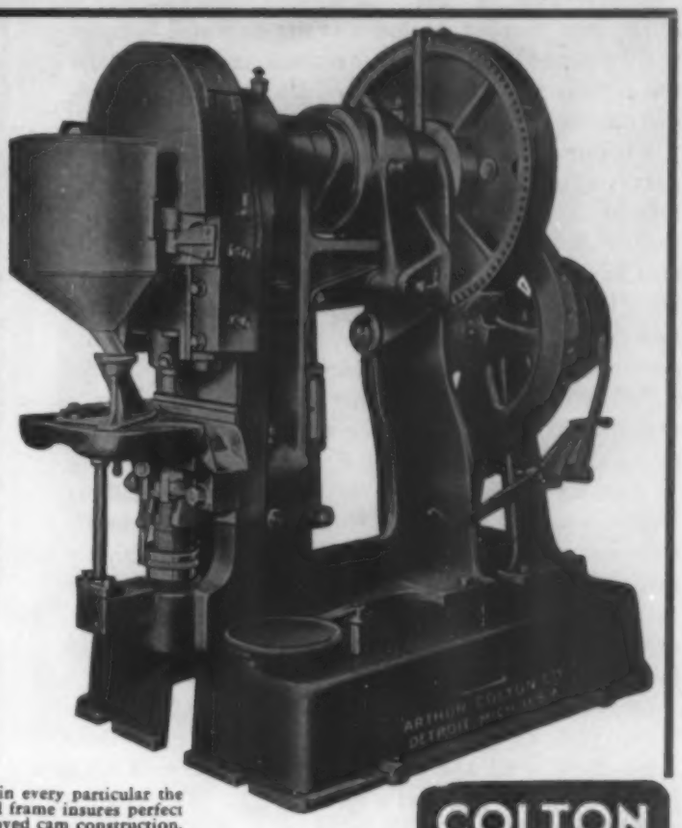
In their plants, the Ford industries employ many Colton Presses for the compression of preforms of phenolic resin and similar materials. Also our Presses are used for the compression of metal powders. This requires not only great strength, but precision as to weights and measurements, and the constant use of these machines demand stamina which make them dependable and economical.

Other motor car manufacturers, including General Motors and Chrysler, as well as many other industries such as General Electric, National Carbon, Colt Patent Fire Arms, Otis Elevator, Moraine Products (they have twenty-four machines), use this same type and size machine in their plants for similar work.

When visiting the Fair see this machine running, notice its smooth, silent operation, without strain or laboring. Possibly you need such a machine in your plant. Let us tell you more about it.



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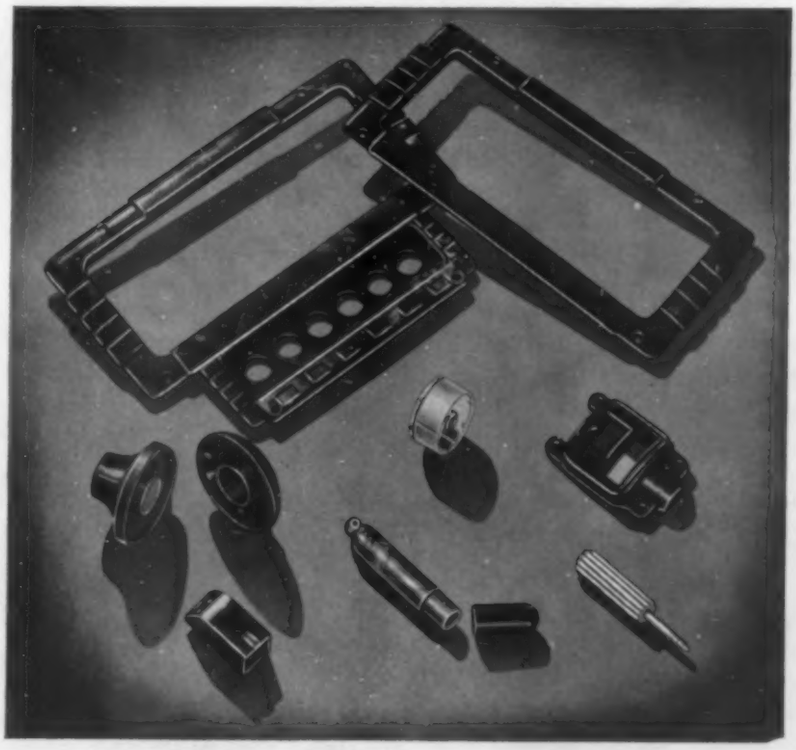

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The improvement in gloss and the decreased "orange peel" finish of a molded part that are secured through the use of preheating make it a requisite procedure on cameras, instrument cases, and similar moldings.

With the wide variations in temperature and humidity that are encountered with the summer and winter seasons, it is almost required that the material be given a preheat before molding. There have been several instances where material has arrived in a plant after a long truck haul in the dead of winter, and was so cold that the cure cycle had to be increased 25 percent to overcome the slow cure caused by cold powder.

Preheating may range all the way from warming the material at 100 deg. F. up to the ultimate, where the material is heated at 250 deg. F. to 290 deg. F. for 15 to 30 minutes and is truly in the plastic stage when put under pressure in the dies. This latter stage is to be desired but can only be achieved if the molder is a highly skilled operator who will hold to a given cycle with little variation, as any slip which causes him to miss a cycle, or unduly prolong one, will result in a tray of pills so far advanced that the material cannot be molded.

One of the most successful preheating ovens used today is made by the molder himself. It consists of an insulated chest with a door on the front equipped with hinges at the bottom and a spring catch. This oven is roughly $2\frac{1}{2}$ ft. by $3\frac{1}{2}$ ft. by 18 in. deep, measured on the inside dimensions, and has a serpentine coil of $\frac{3}{4}$ in. pipe along the inside bottom, back and two ends, through which exhaust steam from the presses flows to supply heat. The oven has two shelves formed by metal rods on which rest eight perforated metal trays. These ovens are placed on the work bench before each press and are heated to 290 deg. F.

If the job in production requires a fairly long cycle, the molder may use only three trays. On the other hand, with a short cycle all eight trays may be used. In any event, the pills are heated until they are thumb-nail soft and may be distorted with slight pressure.

The ideal preheating oven should have the following characteristics:

1. Uniform temperature in all parts of the oven.
2. Circulating air by means of either natural draft or by the use of fans.
3. Some means of regulating the temperature to a ±5 deg. F. limit.
4. Trays for at least 8 mold charges.
5. Good insulation.
6. Trays should be readily accessible.
7. Small over-all dimensions so that an oven may be placed on the work bench before each press.

It is only recently that manufacturers of ovens have designed equipment specifically for the molding industry, and lately several ovens have been offered which fulfill the above requirements.

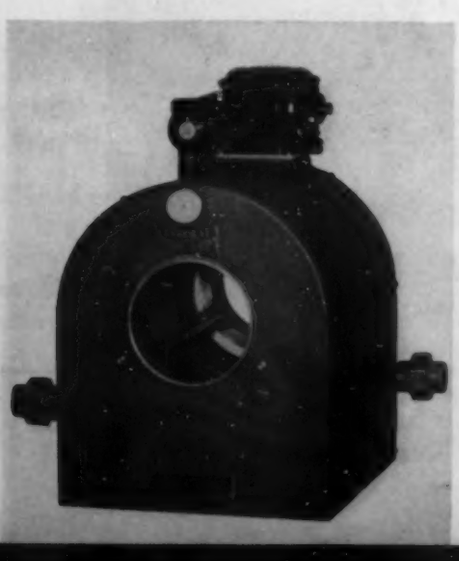
Major efforts to date by one of these manufacturers have been on the drawer type or sectional type units. Compared to the simple home-made type mentioned above, these are rather elaborate and naturally are somewhat more costly. However, they do offer many advantages and more nearly fulfill the requirements of an ideal, all round type.

All the ovens illustrated are electrically heated. It is possible to equip with a gas-heating system or with a steam-heating system. These types are more expensive and seem to be less convenient. It is contended that control is less accurate than in the electrically heated oven. Cost of electrical operation is not at all excessive and the manufacturers believe that with the advancements being made in design and construction this type will become more universally used.

The manufacturers' problem is to produce an oven that will meet the average requirements. Those produced so far are essentially tailor-made to the individual molder's plant set-up or production layout. They are somewhat larger than the average plant requires or has space for.

The small ovens illustrated are for rotary type preheating of powder. Single drum ovens or those for four, six or eight drums are being manufactured. There is also in production a single rotary drum unit which is continuously set at one end and releases the preheated powder at the other end.

Manufacturers have been quick to admit that they are not only willing but anxious to accept constructive ideas, designs and suggestions from those in the plastics industry who wish to offer them. They are typical of the industry in their interest and sincere desire to cooperate for the advancement of the plastics industry.



Rotary ovens for preheating molding compounds are made with a single drum or with a series of four, six or eight drums, electrically heated with automatic temperature controls. Those at the left are manufactured by Chas. F. Elmes Engineering Works

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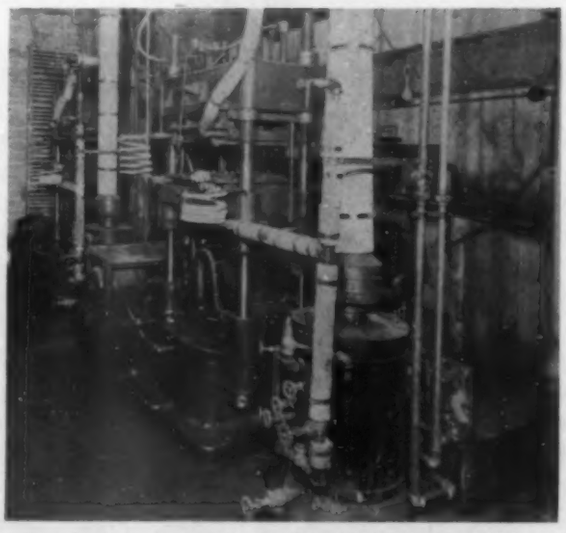

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RESIN PLANT DESIGN

by A. BROTHMAN and H. KAPLAN*

THE DESIGN OF RESIN PLANTS IS OFTEN A DIFficult problem involving critical heat-transfer problems, dehydration problems, foaming problems, refluxing problems as well as problems in the choice of metals for fabrication of the various parts of the plant. These problems are becoming more acute as the specifications of the produced resins become more and more stringent. The color characteristics of resins as well as certain other physical and chemical properties have been demonstrated to be due to certain functions, which may vary for any particular resin, such as: the presence of local overheating of the resin in the resin-manufacturing kettle; the length of time taken to get the batch of raw products up to temperature; the time given to refluxing and to dehydration; the rate of reaction and the temperature at which the reaction takes place; the presence of air in the manufacturing kettle and the extent to which the same is whipped into the resin-producing reactants. The factors in the design of resin plants which have the most to do with bringing each of the above named functions within control are discussed below.

Mixer units for resin kettles

The problem of selecting the means of agitation for a resin kettle is probably the most important in effecting proper rates of heat transfer, in preventing local-overheating and in maintaining adequate contact between the reacting materials. The problem is further complicated in the manufacture of those resins which require that a blanket of CO_2 be laid as a preventative against oxidation of the resin. The several types of agitators which have found use in resin kettles include paddles, propellers, turbines, horseshoes and various combinations such as paddle and horseshoe, and turbine and horseshoe.

Paddle type agitators, either flat or bevelled, are generally given peripheral speeds from 250 ft. per min. to 350 ft. per min. as a maximum and usually have a spread equal to from 60 percent to almost the full diameter of the inside kettle. The arms of the agitator may be staggered so as to accomplish a better distribution of the mixing force or they may form one continuous spread, but in any case the type of mixing action is the same. That is, mixing is obtained by application of a rotation moment to a cylinder of material with a diameter equal to the diameter of the paddle spread and a height equal to the width of the paddle, and by the rotation of that cylinder against the resistance to shear over the full area of contact of the aforementioned cylinder with the surrounding material. The moment of inertia of the surrounding mass, and hence the resistance to shear, may be increased through the use of "off-wall" baffles of various types. The mixing action however, even despite bevelling of the blades, remains concentrated in the immediate vicinity of the path of the paddle and hence the uniform distribution of the mixing force depends upon the use of such a number of baffles, especially in high viscosity mixing systems, as will overcome this localized type of mixing. Especially where the problem of mixing the resin-producing mass includes the laying down of a blanket of carbon dioxide does this type of agitation become impractical since the gas-feed pipe outlet even when located close to the periphery of the sweep of the paddle, the point of greatest turbulence, will be found to give a poor distribution of the gas in the mass of reactants.

Propeller type agitators have to some extent been used in resin kettles, particularly in small resin kettles. The principle on which this unit acts is the thrust delivery of a cylinder of material of a diameter determined by the pitch diameter of the propeller and at a rate determined by the pitch of the blades. These units are most efficient when operated in draft tubes where the tendency toward centrifugal expulsion and the tendency toward deflection of the cylinder of material, especially in those viscosity ranges encountered in resin kettles, is minimized. At best, it will be found that propeller units, depending as they do upon the deflection of the afore-mentioned propelled cylinders from the floor of the kettle, become most inefficient as the viscosity of the "mix" increases since the loss in particle-velocity (impulse) both in deflection and in the subsequent climbing of the wall is very large. The efficiency of the propeller in distributing gases especially when fed close behind the propelling face of the unit may be said to be better than that obtained with paddle agitators, but inferior to that obtained with the correct use of turbine agitators.

The unit which has enjoyed the most extensive use in resin kettles is the horseshoe type of agitator. The unit usually consists of a member conforming in shape to that of the kettle and operating at a clearance from the kettle wall varying from $\frac{1}{8}$ in. to 2 in., depending upon the size of the kettle and the possibility of build-up on the wall during the processing period. Such an agitator, especially in the larger size units, may be constructed with cross-bar members running from one vertical arm to the other thus combining a paddle effect with the scraper effect of the horseshoe. (This is not the paddle and horseshoe combination referred to above.) The action of the horseshoe is to impel material in its path against the resistance to shear of that material with the material on either side of the horseshoe and against the friction of the mass against the walls of the kettle. Efficient design of horseshoe units precludes, especially at high consistencies, the use of peripheral speeds much in excess of those used for paddles, and may, where the clearance from the wall is quite small, be reduced substantially under that figure. The horseshoe type of agitator as well as the paddle type gives a localized distribution of

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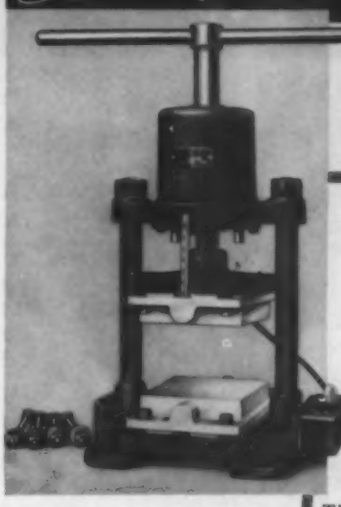

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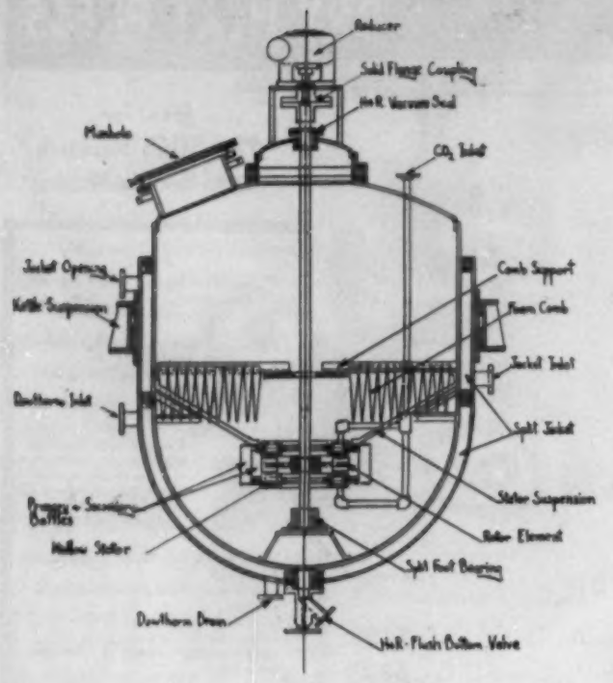

Fig. 1. Vacuum Resin Kettle

the mixing force, the mixing action being largely in a single horizontal plane with little translation of portions of the material at the top of the kettle to the bottom or from the center of the kettle to the periphery. Hence, the over-all heat-transfer figure for kettles containing such units must necessarily be taken at a minimum for agitated kettles. Where the distribution of carbon dioxide is a factor the locating of the gas-pipe outlet must necessarily be above the level of the highest cross-arm member and the failure of this type of unit to give an efficient interchange of portions of the batch lying in different planes causes a poor gas distribution.

From the standpoint of obtaining the maximum practical heat transfer as well as from the standpoints of obtaining the maximum possible interchange between different levels of materials in the batch, the turbine type of agitator is unquestionably the best. The principle of agitation behind the turbine type of agitator, when functioning properly, is that of a pumping mechanism and the agitation may be predicted at least theoretically in terms of the gallon-per-unit-of-time pumping capacity of a properly designed rotor at any definite peripheral speed. The feed to the turbine is theoretically into the immediate vicinity of the hub and the delivery is tangential to the circumference of the rotor. This tangential delivery of the rotor which would ordinarily cause a swirl in the liquid mass may be baffled by the friction of the material on the walls of the resin kettle, when dealing with resin-producing formulations of unusually high viscosities, or it may be baffled by the use of radial deflector plates immediately surrounding the rotor, or by fins welded to the walls of the tank. This last mentioned practice is not to be recommended, particularly in the cases of resins sensitive to local over-heating, since fins placed in such a manner will produce a dead spot fore and aft of the fin, particularly in high viscosity materials. Baffling of the swirl is always best accomplished by the use of an adequate number of radial baffles. Since, for ideal operation, the turbine unit must operate by circulating materials lying above and below the level of the rotor through a vortex, that is, since the unit must approach as closely as possible a pumping mechanism, it is important to avoid a common error in the use of turbines when low viscosity formulations are involved, namely the use of the turbine as a multi-bladed paddle. To avoid this contingency, in many cases the peripheral portion of the turbine wheel is shrouded by means of two flat rings covering all of the blades except that portion closest to the hub. While this method may in a large way overcome this shortcoming, it does not completely since the revolving ring is itself capable of imparting to materials coming in contact with it a momentum which prevents the ring from acting as a limiting impeller rotor inlet. The end-result of the aforementioned type of ring may be to reduce the volume of material circulated by the rotor, not by reason of a restricted inlet but because of the application of an impelling force by the ring to materials in contact with the rings. Where the mixing problem is complicated, as previously stated, by the necessity of distributing a blanket of CO_2, turbines are generally set up with gas-feed pipes delivering into the spokes of the turbine element and close to the hub. The gas is thus distributed by means of shear it suffers in its frictional contacts with the mass of material through which the turbine-delivered charge is impelled. The efficiency of the gas delivery is thus a function of the extent to which the turbine element fulfills its function as a pumping mechanism rather than as a multi-bladed paddle.

Fig. 1 shows a mixer unit set up for operation in a kettle used for the manufacture of an alkyd resin. The turbine element is overhung and underhung by stator elements which fulfill the functions of limiting the charging of the turbine element to that area immediately surrounding the rotor hub, which by means of the CO_2 feed to the hollow stators and the gas ejection thru apertures on rotor-faced surfaces of the stators insures the uniform *injection* of the circulated mass and which gives a finer resultant bubble size due to the wiping or spatula action of the circulated charge against the gas aperture, and, finally, which causes the imparting of a *direct* mechanical shearing action to the circulated material by reason of the stator and rotor relationship. The swirl produced by the tangential delivery of the rotor plate is radially deflected by the primary and secondary baffles indicated in the above drawings. Due to the further complicating factor of foaming in the reaction charge, a relatively small baffling area was used and a considerable amount of the swirl was allowed in order that the foam be subjected to the *foam-breaking* and ploughing action of the stationary comb-member. The above-indicated 18 in. turbine rotor element operating in a 48 in. I. D. kettle and operating at a peripheral speed of approximately 650 ft. per min. is sufficient to command,

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in a state of great turbulence, a charge equal to the full operating capacity of the unit (250 gal.). At the rate of translation of material thus obtained, the over-all heat transfer coefficient for Dowtherm at 680 deg. F in the jacket is approximately 57 B.T.U.'s per min. per sq. ft. per degree. This same degree of transfer may be maintained for any size of batch providing an equivalent rate of translation of material is produced. Where, for the maintenance of the indicated rate of translation, a rotor peripheral speed greater than 800 ft. per min. or a rotor diameter greater than 1/3 that of the kettle diameter is required, two or more rotors spaced above each other on the same shaft should be used. The spacing between rotors is equal to the ratio of the theoretical pumping capacity of the specified unit for the viscosity and specific gravity of material involved to the theoretical pumping capacity of the same unit for water at a peripheral speed of 600 ft. per min. multiplied by the diameter of the rotor. If a serious problem in the prevention of oxidation is encountered both of the mixer units may be of the gas-liquid type or, if this is not the case, the gas-liquid unit should be the one placed deepest in the kettle while the other unit or units may be those of the shrouded turbine agitator type. In any case, no single rotor should be used to maintain in agitation a height of material greater than one and one-half times its own diameter in either direction regardless of whether additional pumping capacity to make up for the increased commanded height is specified or not, since such a condition will result, in many cases of high viscosity mixes, in the local over-agitation of any one place in which the rotor may be located.

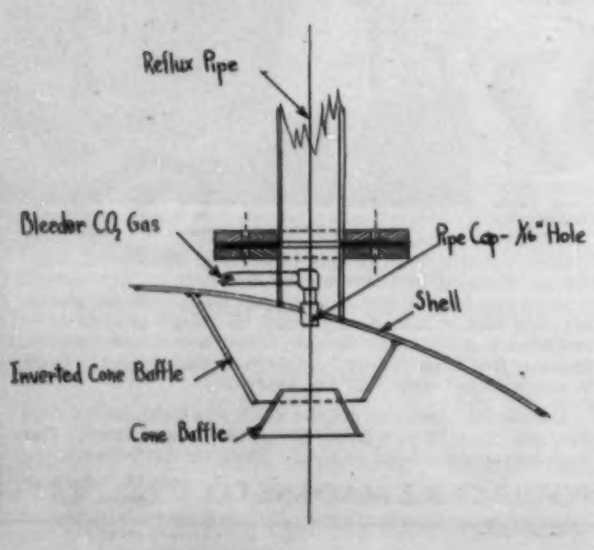
Heating and cooling of resin kettles

Methods of heating kettles include direct firing of the kettle by gas or oil burners, by the encasing of the kettle with electrical resistance units, steam, hot oil-circulating systems, and Dowtherm units, the individual chosen unit being determined by the fire hazard involved, municipal ordinances and the temperatures involved. Where direct firing of the kettle is contemplated by the designer, liberal allowances in plate thicknesses above that required to withstand any collapsing or other type of pressure should be made to take care of temperature-difference stresses encountered in the metal and of losses in tensile of the metal involved with continuous firing of the kettle. In such cases, and especially where the resin involved is sensitive to local overheating, the flames of the burner should be applied to the estimated center of maximum turbulence in the kettle. For fairly obvious mechanical reasons flames should never be played upon the bottoms of flat-bottom kettles. In particular, such kettles because of the dead-spots created at the seam, create the greatest danger of local overheating when so heated.

Electrical heating units applied to the outside wall of the kettle have had a fairly common usage, and are vastly superior to direct-firing methods in that the heating is more uniformly distributed. The expense of installation of such units as well as the difficulty of arranging for efficient cooling of the charge either by air or other means where resin processes involve not only an initial heating of the batch to temperature but also a subsequent period of removing of the heat of reaction, have combined to speak against such units. There are, however, a fair number of cases of electrical heating of an immersion bath which itself was used to heat the kettle and where cooling coils running through the bath provided the means of cooling when required. The problem involved here is too straightforward to demand treatment.

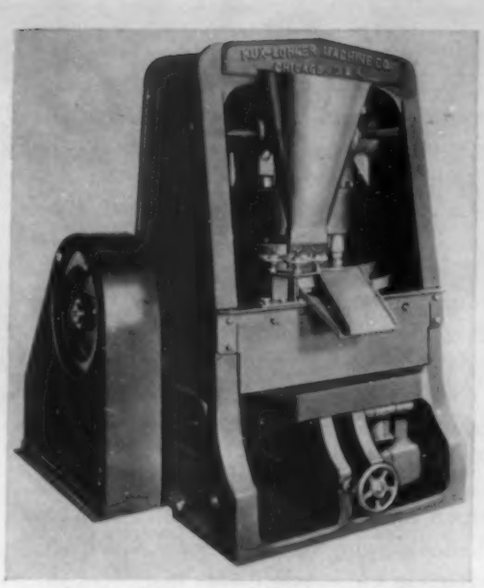
Regarding jacketed kettles, regardless of whether the same are used for steam, circulating oil or Dowtherm, the following considerations have been proved to be helpful in the design of same. Fig. 1 indicates a split jacket in the case of a Dowtherm jacket. The advantage obtained by its use in this case is the restriction in the passage of the heating vapors to that portion of the kettle in direct contact with the charge during the heating-up period, while during the dehydration period as well as during the refluxing period the vapors may be heated in the one case, assisting in dehydration, and cooled in the other case, thus reducing the burden on the condenser. In larger units, two or more sections may be used to accommodate various batch sizes. Care must be taken, however, in providing return lines with adequate valving controls so that the falling off of pressure in any single portion of the jacket, during the continuance of normal pressure in any other portion of the jacket will not result in the sucking up of condensate into any single portion of the jacket thus possibly creating a dangerous lowering of the liquid level in the boiler, regardless of type. Despite the additional cost of the split type of jacket, the advantages in operation indicated above will more than compensate for increased expenditure.

Fig. 2. Reflux and Dehydration Condenser



Refluxing and dehydration

Fig. 2 indicates a 3-in. reflux pipe, fairly large for the amount of vapors to be handled per unit of time but so specified to take care of any fouling of the reflux pipe in the event of any particularly unusual case of foaming and



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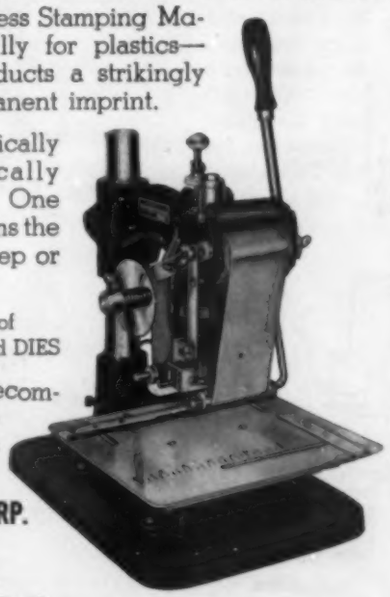

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consequent reduction in the vapor density in the pipe. It will also be noted that the reflux connection is provided with a $^1/_2$-in. I.P.S. nipple welded to the reflux and terminating in a capped nipple, the nipple having a single $^1/_{16}$-in. diameter perforation. This CO_2 bleeder arrangement, functioning in conjunction with the cone baffles which direct any possible foam into the path of the bleeder, forms an anti-foaming arrangement capable of preventing the climbing of the foam into reflux pipe or into the condenser. Naturally, added capacity in the vacuum pump must be provided for to take care of the quantity of CO_2 or other inert gas which may be bled in if necessary, when vacuum is used, or if foaming is apt to occur during vacuum dehydration.

It will also be noted (Fig. 3) that instead of a separate reflux condenser and a separate vacuum condenser that the instant design calls for a single straight-tube type of condenser equipped with an automatic flap-valve or swing-check which closes during vacuum dehydration and which opens during refluxing. The advantages of the above combined reflux and vacuum condenser are the saving of expense in the avoidance of the duplication of units and the reduction in cumbersomeness of the plant.

Thinning of produced resins

Almost all resin thinning operations are conducted with turbine type agitators (of various designs) or by means of high-speed paddles which approximate the action of a turbine-element. As distinguished from the paddles mentioned in a previous section of this article, the paddles now mentioned will run in a spread from 50 percent of the inside diameter of the kettle to 25 percent of the same.

The rapid thinning of any resin depends upon the application of shear to the solvent-soaked resin agglomerants and the dispersal of the reduced agglomerants through the mass of solvent. Shearing as performed in mixers may be of two kinds, direct and indirect, the former being the result of the isolating of any portion of the batch between any two units moving at different speeds or having to each other the relationship of stator and rotor and the latter being the result of frictional relationship between an impelled particle and the mass through which it is impelled. Shearing as performed by a turbine or paddle which is neither surrounded by a muffling cage nor overhung or underhung by a stator element is almost totally of the latter type.

Fig. 3 includes a resin thinning kettle. Similar in construction to the unit previously described (see Fig. 1), the turbine rotor works with small clearances from overhanging and under-hanging stator elements which act to seize agglomerants in the impeller inlet subjecting them to a preliminary shearing action, and then secondarily subjecting the agglomerants to a shearing action between stator ribs and the rotor ribs. Unhampered by the "choking" of clogged cages, as in the case of standard turbine thinners, this type of unit combines a high circulating capacity with a high direct-shearing capacity, thus giving the best combination of complimentary mixing actions.

It will be noted that the thinning tank is provided with a reflux condenser against the loss of solvent in the addition of hot resin to the solvent or because of heat developed in solution and mixing. In so doing, the necessity for providing a jacket for the thinning tank is done away with and also the possibility, in a great many instances, of impinging of a chilled agglomerant on the wall of a tank is reduced.

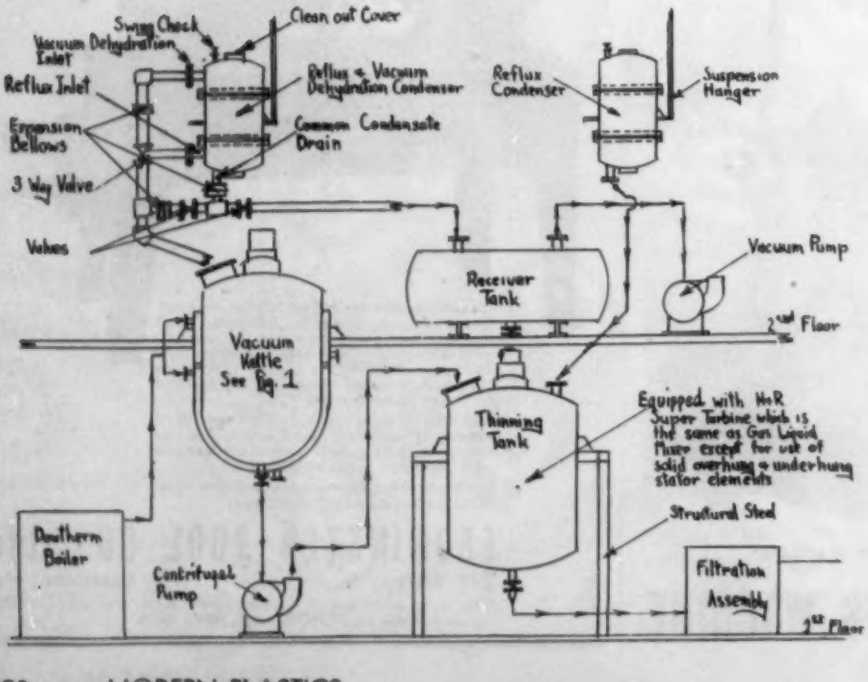

Fig. 3. Plan of Typical Resin Plant Installation

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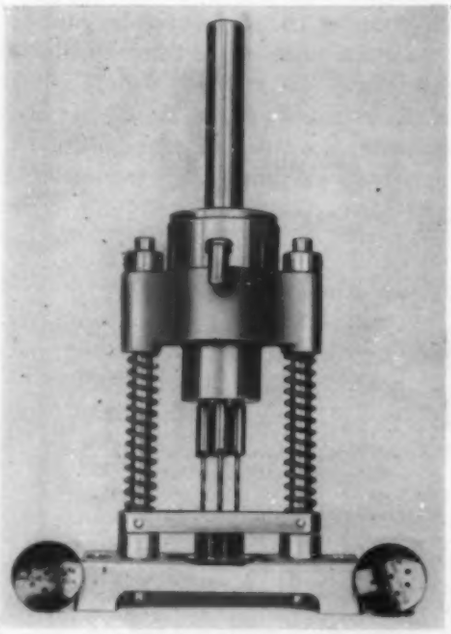

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by JACK GEERS*

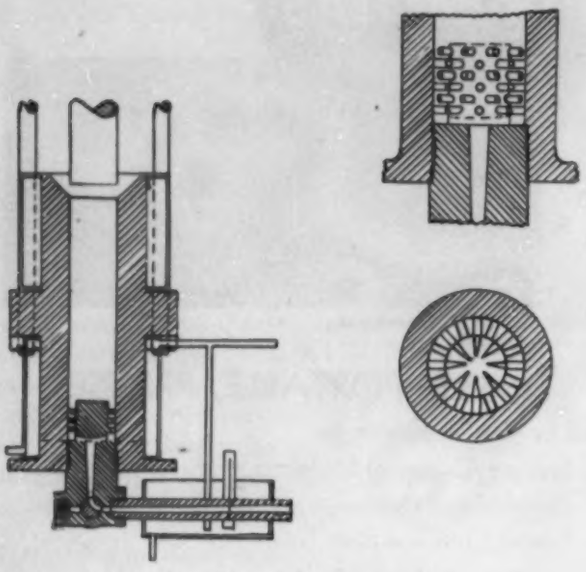

Fig. 1

Many of the same principles employed in present-day heating cylinder design were embodied in the Hyatt machine for which a patent was granted in 1872. A section of the heating cylinder used on that machine is shown above. In 1932 a patent was issued to Hans Gastrow covering the heating cylinder on the Isoma injection press. The sketch (below) shows this cylinder as described in the patent

MUCH HAS BEEN SAID CONCERNING THE ADvancement of injection molding in the past four to five years. When we visit the plant of the American molder today and see in operation injection molding machines which produce regularly castings that weigh as much as 12 oz. or more, it is difficult to realize that just four years ago these same plants were making their debut in the plastics industry.

During this short period of time injection molding in the U.S.A. has advanced from a stage where 1 oz. castings were considered an achievement, to the position where 12 oz. castings are accepted as a fact.

This rapid development is truly a tribute to the American spirit of cooperation. It is only through the close cooperation of the material manufacturer, the machine builder, the mold designer, and the molder that this remarkable progress could be achieved. Today it is possible for the American molder engaged in the injection molding of thermoplastic materials to secure machines which can successfully inject castings up to 12 oz. in weight with a single-injection cylinder. He can also secure larger machines which can produce 32 oz. castings by use of a series of injection cylinders.

It is the purpose of the author to review in this short discourse the development of the single-cylinder injection press and to point out some of the factors which influenced its development.

A brief survey of the patents issued on the subject of extrusion discloses that on November 19, 1872, a patent was issued to J. Smith Hyatt and John W. Hyatt covering

*Index Machinery Corp.

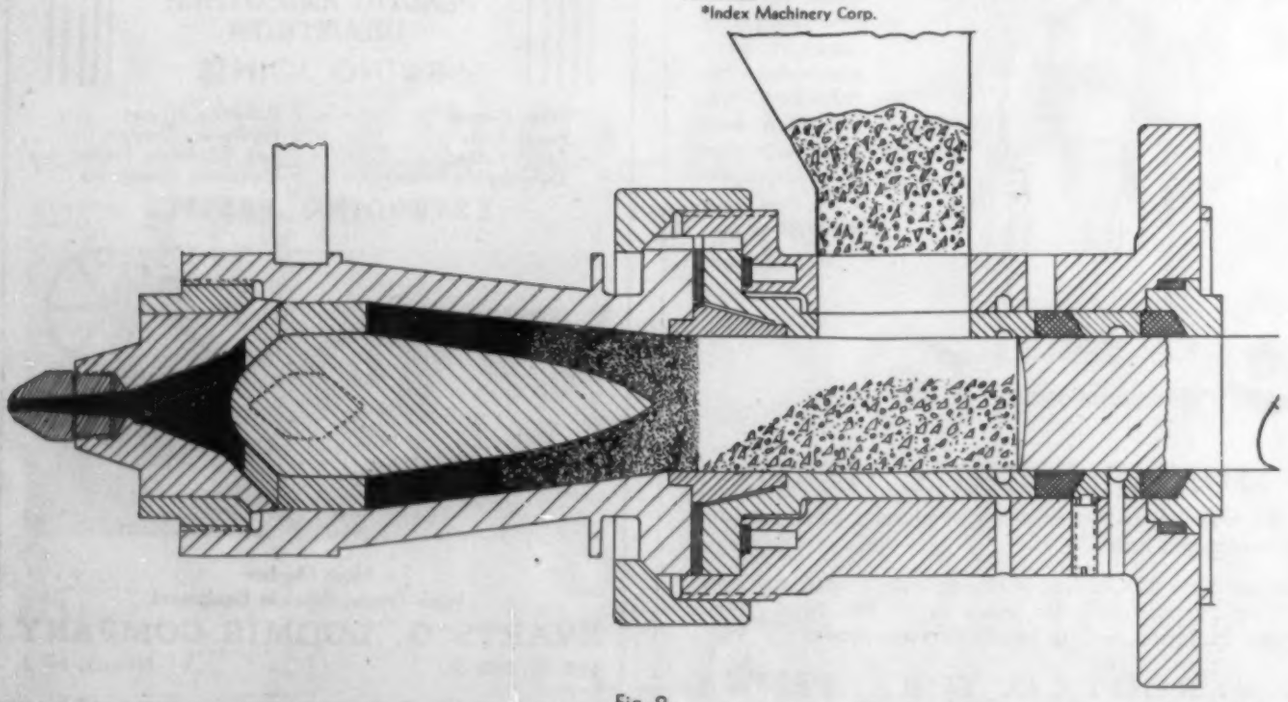

Fig. 2

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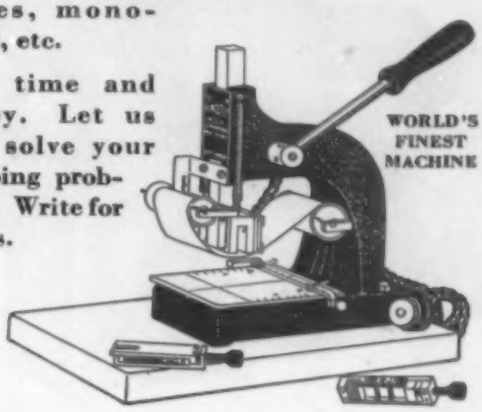

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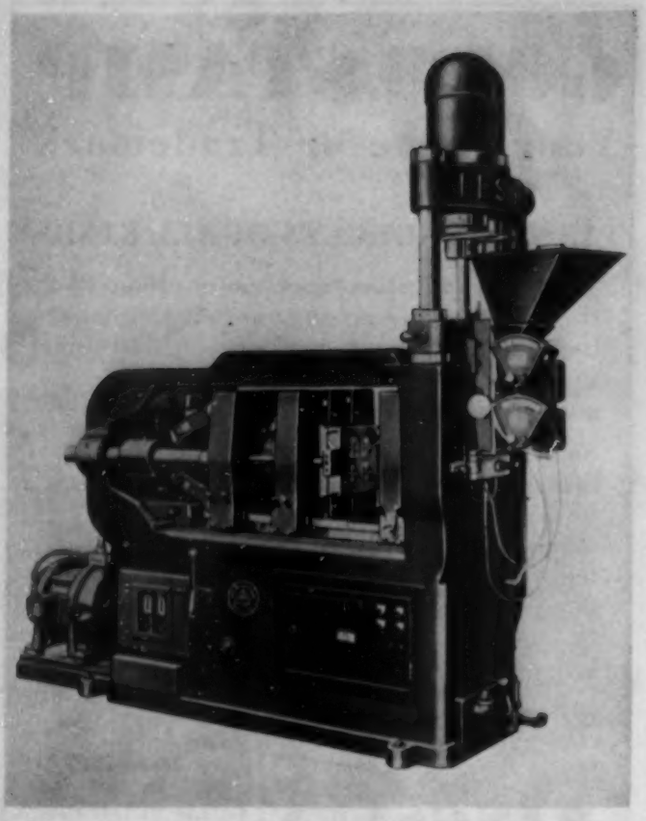

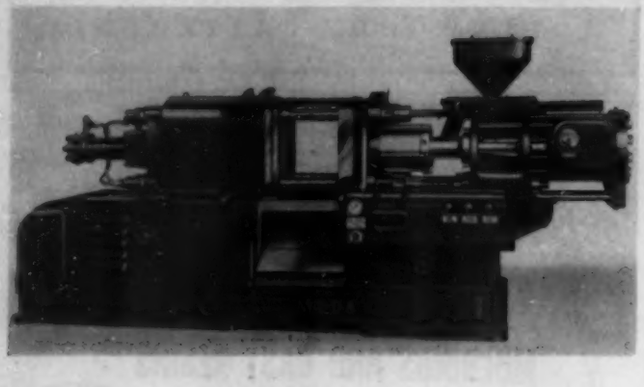

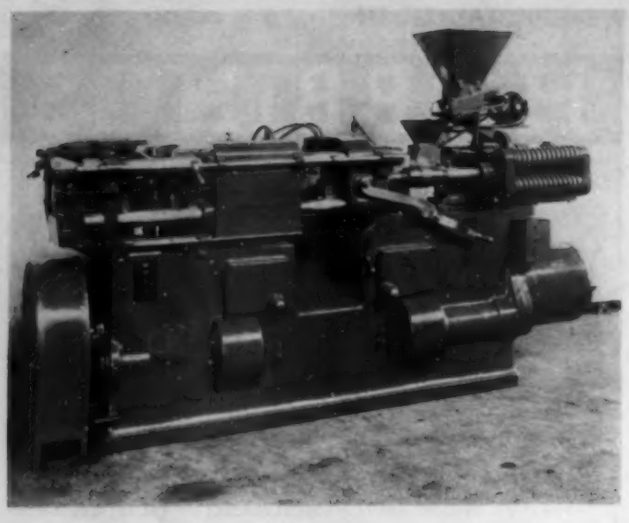

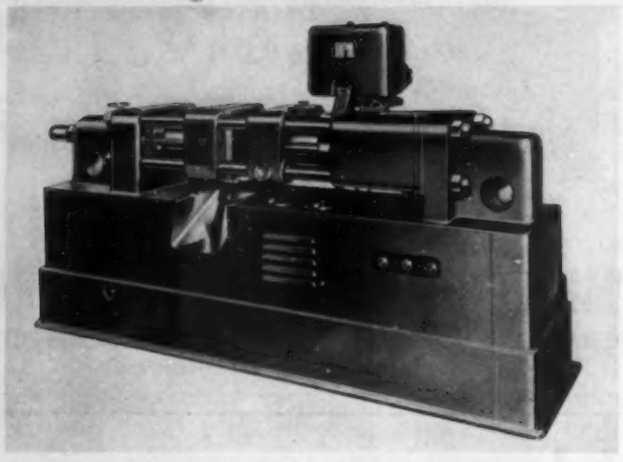

(Top left) Lester designed, fully automatic injection molding machines are available in standard capacities up to 12 ounces. With these machines the plastic compound is injected by hydraulic pressure from a vertical ram, while the mold is opened and closed by a horizontal ram. (Top right) A 4-oz. capacity De Mattia horizontal injection press, that is operated mechanically. (Lower left) Reed-Prentice 8-oz. injection machine that operates manually or automatically as desired. (Lower right) Operating at the World's Fair is a 2-oz. H.P.M. injection press with a plasticizing capacity of approximately 24 lbs. of material an hour

a machine for the extrusion of celluloid. This machine embodied in its heating cylinder many of the same principles that are employed in the design of the heating cylinders on our present-day machines.

Fig. 1 shows a section of the heating cylinder used on the Hyatt machine as shown on patent No. 133,229. Referring to this figure it will be noted that the cylinder contains a central core, the purpose of which was to reduce the thickness of the section of the material and thereby secure thorough plasticizing of the material as it progressed through the cylinder. The central core as well as the outside shell contained many pegs which protruded into the path of the material and gave added surface for the material to contact and absorb heat in its passage through the heating cylinder.

Due to the ever-present danger of explosions when celluloid is subjected to heat and pressure, the development of this machine for purposes other than the extrusion of rods or tubes was greatly hampered.

As time progressed, a new material, cellulose acetate, was offered as a molding material. This material was thermoplastic and non-explosive and was readily adapted to the process of injection molding. With the development of cellulose acetate molding powder and various other thermoplastic materials, interest in the injection method of molding gained much momentum.

Patent No. 2,057,945, issued to Hans Gastrow on December 10, 1932, covered the heating cylinder used on the Isoma injection molding machine. The sketch in Fig. 2 shows this cylinder as described in the patent.

It is to be noted that this cylinder is streamlined throughout and reduces greatly the friction developed

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between cylinder and the material as it is forced through it. This design did much to eliminate burning and discoloration which results if material is forced through a cylinder with the construction shown in Fig. 1. By streamlining the cylinder the danger of having material collect inside of the cylinder and be subjected to the heat of the heating cylinder for too great a length of time is eliminated because no pockets are created where the material can lodge.

With the introduction of this machine on the American market the interest in the injection method of producing castings from thermoplastic materials was soon aroused. The possibilities of this process were recognized and it was only a short time until the importance of injection molding began to assert itself. Its practicability as a method of production was quickly acknowledged and presently demands for larger machines were heard.

One of the greatest problems involved in this development of larger machines was the design of a suitable heating cylinder. Experience proves that it is absolutely necessary for the heating cylinder to be designed so that the wall thickness of the material to be heated is kept sufficiently thin so that the heat will penetrate the material rapidly, and insure plasticization. On the other hand it must not be so thin that the internal friction set up in the cylinder between the walls of the cylinder and the material will greatly reduce the effective pressure when the material is forced into the mold.

It is evident that in the last cylinder discussed above, one dominant problem asserts itself. The material enters the cylinder in a granular form. As it is forced forward by the injection plunger it must be broken up over the end of the spreader and forced into a thin section to permit plasticization. This breaking up requires considerable pressure, and as larger capacity machines became necessary the problem became more involved.

It was discovered that the type of construction shown in Fig. 2 was successful for machines where the capacity of a single injection was 1 1/2 oz. or less. If larger capacities were attempted the pressure exerted against the tail end of the spreader would loosen the joint between the spreader and the outside shell of the cylinder, thus permitting material to get into the joint and burn.

In Fig. 3, another development in the design of heating cylinders is shown. In this cylinder the central core is made integral with the outside shell of the cylinder, thus eliminating the joint between the central core and the shell of the heating cylinder. This removes the possibility of having material force itself into the joint and burn, causing discoloration of the material.

As cylinders of this third type were built in larger and larger capacities a point was reached where the pressure exerted in forcing the material over the end of the spreader caused a tremendous loss in pressure and materially reduced the effective pressure on the injected material.

In order to overcome this difficulty cylinders were constructed with the plunger moving over the spreader as shown in Fig. 4. With this design the material enters the cylinder around the spreader shaft and does not have to be broken up after it has been compressed. This latter

Fig. 3

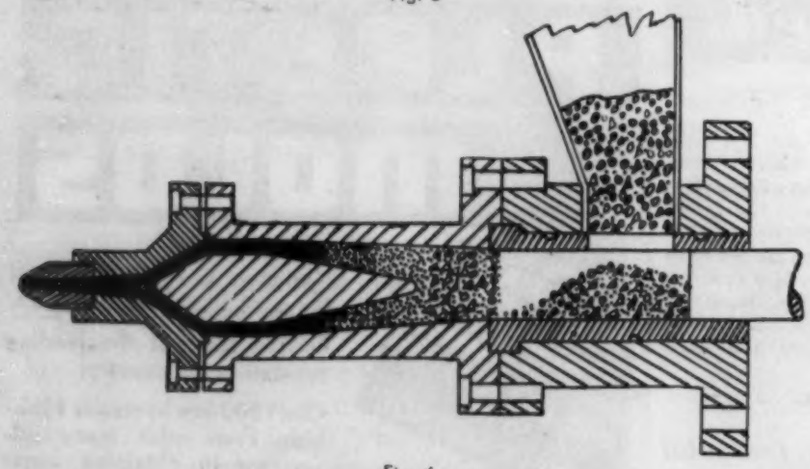
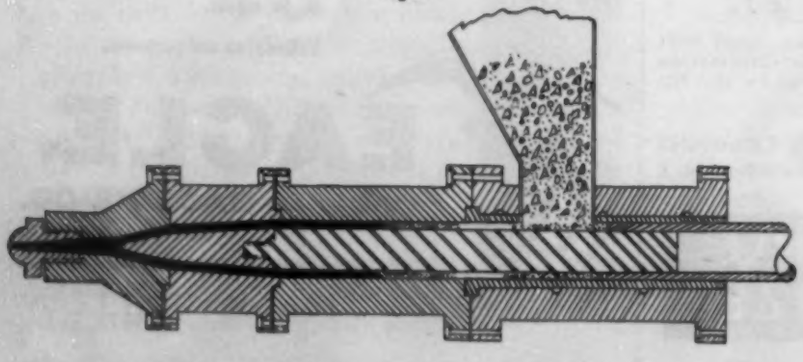


Fig. 4



(Fig. 3) A heating chamber in which the central core is made integral with the outside shell of the cylinder, eliminating the necessity for a joint between the central core and the shell. Fig. 4 shows a cylinder constructed with the plunger moving over the spreader. This was designed to overcome the tremendous loss in pressure that developed as larger capacities were built of the type sketched in Fig. 3

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The Grotelite Company was among the pioneers of injection molding presses in this country, and one of its current machines is illustrated at the left

Watson-Stillman Co., long famed as compression press manufacturers, has recently begun production of the Wasco automatic injection presses. A battery of them, installed for Universal Plastics Corp., is shown at the right

type of cylinder construction has been successfully used on single-cylinder injection presses for the production of castings as large as 12 ounces.

Since the design of the cylinder for any injection molding machine is directly dependent upon the characteristics of the molding material to be used, it is difficult to determine just what the limits for the single cylinder press will eventually be. Improvements in material continually tend to increase the possibilities for the construction of single-cylinder presses of larger capacities.

Modern production with its ever-increasing demand for machines that are simple and dependable in their setup and operation, gives a definite position to single-injection cylinder presses in the injection molding industry.

In conclusion, the author believes that the following features of the single-injection cylinder press not only account for its ready adoption by the molding industry in the past, but will destine it for even greater acceptance as time goes on.

1—It is possible to make large castings with a single sprue thus reducing finishing costs and eliminating the weld line which is bound to occur if material enters the mold from more than one source.

2—The control for the single-cylinder press is very simple.

3—In cases where it is necessary to disassemble the heating cylinder to remove one type of thermoplastic material before using another, the single-cylinder will greatly reduce the time involved in this procedure.

The limitation in application of the single-cylinder injection molding press cannot be visualized today due to the constantly changing characteristics of molding materials with regard to flow and plasticization temperature. It is the author's opinion that simplicity of operation must be the watchword in injection molding machines, with the thought of definitely establishing the limitation of single-cylinder injections before resorting to the more complicated or complex methods of obtaining larger castings to meet the demands of the trade.

Pages 399 to 428

LAMINATES

DECORATIVE LAMINATES—400
INDUSTRIAL LAMINATES—406
RESIN-BONDED WOOD—416
TRANSLUCENT LAMINATES—425

DECORATIVE LAMINATES

by W. G. STEINER*

1

2

3

4

SHEETS OF PAPER OR FABRIC IMPREGNATED with phenolic or urea resins with colored surface laminations, which are sometimes printed in wood, marble, or other designs, and cured together under heat and pressure, are known as decorative laminates.

Methods of manufacture

Resins used for decorative laminates are applied in the form of varnishes in which the resinoids are dissolved in solvents. Several different types of varnish may be used in the same sheet. Thus the surface sheet may be treated with urea resinoid mixed with pigment and the body sheets with phenolic resins, or the laminations may be treated throughout with phenolic or urea resins. The varnish is absorbed into the fiber sheet on a treating machine which can be adjusted to pick up a predeter-

* Formica Insulation Co.

At Hal's in Oakland, Calif., (1) the smooth, lustrous sheen of Micarta, designed and fabricated by Plastiform Products, Inc., distinguishes the entrance, as well as the bar and table tops. The Page Dairy, Mansfield, Ohio (2), uses the same material for counters and wall paneling. McCormick Co., Inc., engineers and architects, specified the material which was installed by Micarta Specialties Co. (3) A bar top and panels of Micarta, with simple decoration, fittingly frames the mural that covers the back wall. (4) Light and dark squares of Parkwood-Textolite—thin strips of wood veneers woven together and laminated with resin—combine to form an attractive pattern for the top of the extra-leaf dinette table by Hampton Specialty Products Company

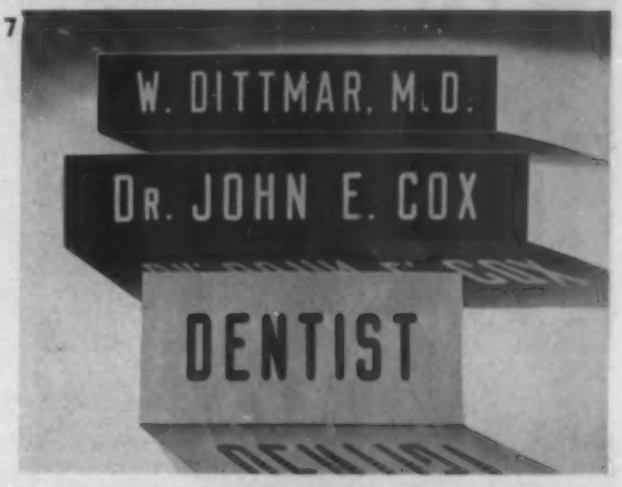
mined percentage of resinoid and which then dries the varnish into the sheet to a predetermined and carefully controlled degree of dryness. The rolls of treated fiber are then cut to sheet sizes, piled up between highly burnished metal plates, and cured in a hydraulic press under varying pressures not less than 1100 lbs. per sq. in. and about 350 deg. F of heat. Patterns are secured by printing the top lamination of fiber before it is treated with resinoid.

Some sheets are also made by using an actual thin veneer of wood either woven or plain as the figured lamination. This is impregnated with resinoid in the usual way and has provided decorators with combinations of rare woods in which the surface life has been infinitely lengthened and improved.

Inlays are made in the sheets by cutting a design of one color out of treated but uncured sheets and laying it over a background of another color. A number of colors may be combined in this way. Or the design may be

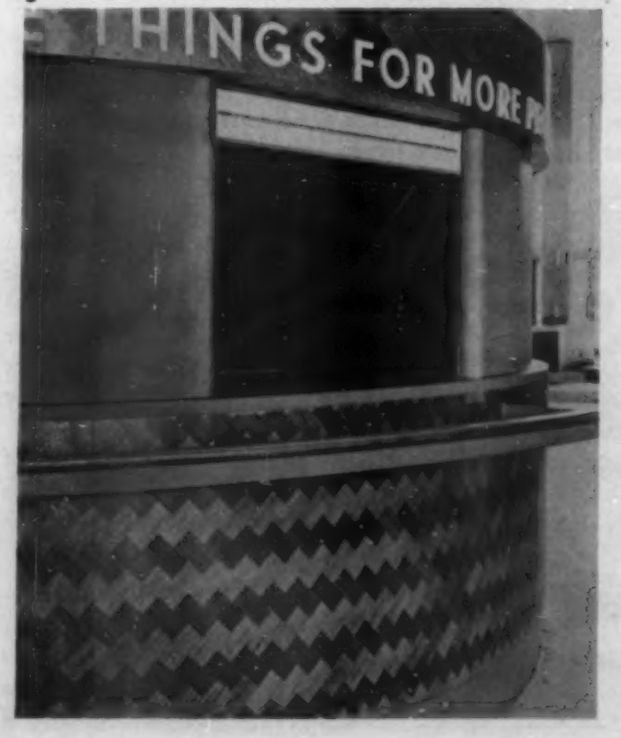
8

7



(5) Contrasting woven laminated wood veneers (Parkwood-Textolite) cover the top and bottom sections of a booth in the General Electric building at the New York World's Fair. (6) The glare of bright sunshine as it filters through translucent Lamicoid Venetian blinds, is diffused to a soft mellow glow, decidedly flattering to interior furnishings. Made by Rex Display Co. (7) The modern version of the professional "shingle" will remain unbattered by weather for years to come. Black signs, cut from Lamicoid sheets, are engraved, the urea core forming permanent letters. Engraved letters on the white sign are filled in with black lacquer. Lamicoid sheeting over Prima Vera wood veneer, forms a decorative durable material for a fireplace mantel (8) as well as for other furniture. The same material in green serves as trim

5



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9

10

The Lounge Riviera, in Washington, takes full advantage of the desirability and practicability of decorative laminates for interiors. For instance, the bar and table tops (9) are of Formica Prima Vera, while the entrance door (10) is of Lacewood, Realwood Formica, with inlaid crest and letters. These laminates were installed by John C. Knipp & Sons

cut from metal foil and laid on a colored background sheet. When the sheet is cured these designs become an integral part of the sheet.

Characteristics of the material

The material has a hard smooth surface and great depth of color. These give it an appearance which is unique among decorative materials and never obtainable before. The surface may be very high gloss if the original finish obtained from curing against a highly burnished metal sheet is allowed to remain. It may be a satin finish if the original high gloss is rubbed with pumice, or it may be a Morocco or grained surface if the metal sheet against which it is cured has been engraved with a figure.

Light colors with a high degree of stability can be produced by careful selection of pigments and by the use of urea resins which maintain their clear white translucency under the effects of sunlight. Phenolic resins, on the other hand, turn yellow under the effects of the sun and sheets where the surface laminations are treated with this resinoid are not particularly stable in color but are inclined to turn somewhat yellow as they age in use.

Decorative laminates are harder than marble and will stand a great deal of wear. They are inert chemically—among the most inert of materials with an organic origin—and therefore will not spot with fruit acids, alcohol or other solvents, or milk alkalies. If a lamination of metal with high heat conductivity is incorporated just under the surface, it will spread the heat from a lighted cigaret or cigar so rapidly that the material becomes completely resistant to burning cigarets. This will not, however, prevent the blistering of the material if a high degree of heat is applied over a large area, as in that case the volume of heat exceeds the capacity of the metal lamination to conduct it away and damage may result.

Developments during 1939

Most of the essentials of the process by which these sheets are now made were developed before 1939, and this year's developments have been largely in the production of

new colors and the development of materials and processes which have somewhat reduced costs and permitted decorative laminates to be sold at somewhat lower prices which have adapted them to wider use.

Urea resins in laminates have expanded by leaps and bounds in the decorative field, and bid fair to point the way to home and building construction. Paneling of houses and offices, restaurants and cafes has now become common, chiefly because of its permanence and the beautiful color effects that are obtainable. Those who still prefer wood grain finishes can now afford at a reasonable cost the most beautiful of woods with a more permanent and better finish than has ever before been available. The newest development involves pieces of wood veneers which are cut to the desired width and woven to almost any pattern that weaving permits. By the use of contrasting woods, and the variety of possible designs, decorative effects can be secured that have not been even anticipated in the past.

Forms available

Decorative laminates are available in the form of $^1/_{16}$ in. veneer sheets which are glued to plywood in a veneer press with casein glue to produce table tops, counter tops, counter panels, wall panels, doors and similar structural parts of fixtures and buildings. They are also available

(11) The Earle Restaurant, at Washington, has table tops, inlaid bar front, wainscoting, counter and paneling of Formica, designed by John Eberson, theatrical architect. This material was chosen for table tops in the cocktail room (12) of the British steamer "Mauretania." (13) A counter with inlaid panels and top of Formica in blue and black, is used by Western Union in the Pennsylvania Station at Baltimore. (14) The dining table in the Royal Suite of Hotel Vancouver, used for the first time by the King and Queen of England, has a top fashioned from Macassar ebony and blonde maple Realwood Formica. Macassar ebony appears on tops of other pieces in the room

11

13

12

14

(15) Formica wall paneling in the bathrooms of the better accommodations on the steamship "Mauretania" is fresh and sanitary in appearance, cleans easily, and is not likely to become scratched or damaged through any amount of use

15

in a sheet of which the center is a highly compressed fiber board, the total assembly being from $^{5}/_{32}$ to $^{11}/_{32}$ in. thick for erection against wood grounds or wood backing as a wall board. They are available also in steel-center sheets. There are a few molded shapes for use as baseboards, window sills and cover molds between sheets of wall covering.

Translucent sheets (also see article: Translucent Laminates, page 425) are made by treating all the laminations with urea resins. These may have opaque surfaces so that the opaque surface sheet may be sandblasted away to form designs through which light will shine. If pigment is added to the center sheets treated with urea, there is produced a white or colored center sheet with an opaque body and opaque surface in a different color. When the opaque surface sheet is engraved away, lettering or designs may appear in white or other light colors.

It is possible also to print lettering and designs on finished decorative laminated sheets in bronze inks by an offset process. These inks are usually mixed with phenolic resinoids and after printing the panel is baked to cure the varnish in the ink, producing a very hard and durable form of lettering. Panels may also be engraved and the engraved lettering or designs filled with gold or silver. The sheets may be hot stamped with the lettering or designs likewise filled with white gold or silver.

Methods of fabrication

The most common method of fabricating decorative laminates is to glue the laminated veneers to plywood. It is the best practice to cover both the bottom and top surfaces of the plywood with plastic veneer so that moisture will not penetrate the core more easily from one side than from the other as that will lead to warping of the assembly. Edges of the plywood may be covered with veneer, using clamps for this purpose instead of a veneer press. In general, decorative laminates which are high in cost, are used as a thin surface covering over a body of less expensive material, such as plywood, compressed fiber board, or low resin content laminates.

Typical applications

Restaurant table tops	Bedroom furniture tops
Wall covering	Counter tops
Doors	Counter paneling
Elevator cab interiors	Soda fountain counters
Signs	Back bars
Inlaid mural designs	Translucent lighting fixtures
Telephone booths	Translucent signs

Card index drawer fronts and cabinet panels

Outstanding Properties

Depth of color	Beauty of surface
Durability	Chemical inertness
Resistance to cigaret burns	Translucency in some grades
	Resistance to spotting or discoloration

Trade names

Formica, Insurok, Micarta, Lamicoid, Panelyte, Parkwood-Textolite.

PLASTICS is Richardson's sole interest. To that end all Richardson abilities and resources are directed to the constant improvement of precision laminating and molding processes. The development of finer plastics and the application of these plastics to a greater variety of industrial and commercial requirements is our major endeavor. Laminated INSUROK, the precision plastic, is an outstanding Richardson contribution to the world of synthetics. It is widely used because of its many time-, labor- and money-saving production advantages, and its ability to impart its own inherent high qualities to every product of which it becomes a part. Whatever your laminated plastics needs, it will pay you to consult Richardson first.

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INDUSTRIAL LAMINATES

by R. V. BOYER*

LAMINATED PLASTICS, AS THE NAME IMPLIES, is a composition of thin layers of material bonded together to form a composite structure having as the bonding medium a synthetic resin. In general, the practice of today is to coat sheets of fibrous material with a resin in a varnish form and by passing the treated sheets through a heated zone, the solvent is driven off, and the sheets are ready to be pressed, under a high degree of heat and pressure, into plates and forms.

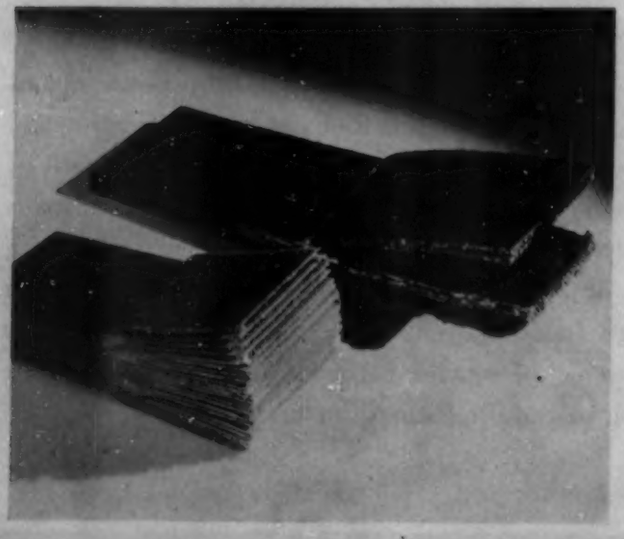
The common fibrous structures used for reenforcing fillers are in matted and woven-fabric forms. The matted or interlocking fiber structures, commonly referred to as a paper, consist of Kraft, Alpha, Wood Pulps, up to the best cotton rag paper and asbestos paper. Each of these papers finds a multitude of applications, where its properties and price are the governing factors. The papers may vary from .001 in. to .040 in. in thickness, depending on the application, and the results desired.

Wood veneer may also fall in this class of cellulose fillers since if pressed under the proper conditions it has enormous strength parallel with the grain. Woven fabrics consist chiefly of cotton, although woven asbestos and more recently woven glass fabrics also play a part. The properties can be varied by a multiplicity of fabric constructions, depending on the grade of staple length of the cotton staple, purity, twist and ply of threads, treatment and weave. The cotton fabric may vary in weight from 1 1/2 oz. per yard to 4 ply interwoven drill weighing 40 oz. per yard. The very lightweight fabrics are used principally to produce a fine structure for intricate machining, and are usually accompanied by a high resin content; while the heavier fabrics are used for such industrial applications as bearings, caster wheels, structural members, etc. In general, the heavier the fabric the higher the impact strength, although this will vary with the type and quality of the fabric. Asbestos cloth finds its chief field in its well known property of heat resistance, and in this respect the limiting feature is the heat resistance of the resin binder itself rather than the filler. However, the dimensional stability of the asbestos compounds is creating many new uses where heat resistance is of minor importance. The inherent lower coefficient of thermal expansion of asbestos fibers and lower moisture absorption permits closer tolerances to be maintained. More recently such fabrics as woven glass have become available and are undergoing active development that will soon widen the field of laminated plastics in improvements of existing applications and new applications at present impractical.

No less important then the fibrous fillers—to this fast-moving phase of plastics—are the synthetic resins that add their individual characteristics to the laminated structure. In addition to acting as bonding media, they impregnate and encase the fibers so as to protect them from moisture, acids, light rays, and other agencies that might affect the individual fibers. They also con-

* Plastics Department, General Electric Co.

A huge hydraulic press (right) accommodates material for 15 sheets of laminated Textolite. These are pressed into a solid homogeneous mass, varying in thickness according to specifications. The two swatches below, one for roll neck bearings; the other a canvas material, show resin treated sheets as they appear before and after the pressing operation



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Turn to pages 201 to 216 for information on Textolite laminated materials and other General Electric plastic products and services.

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Parkwood Textolite

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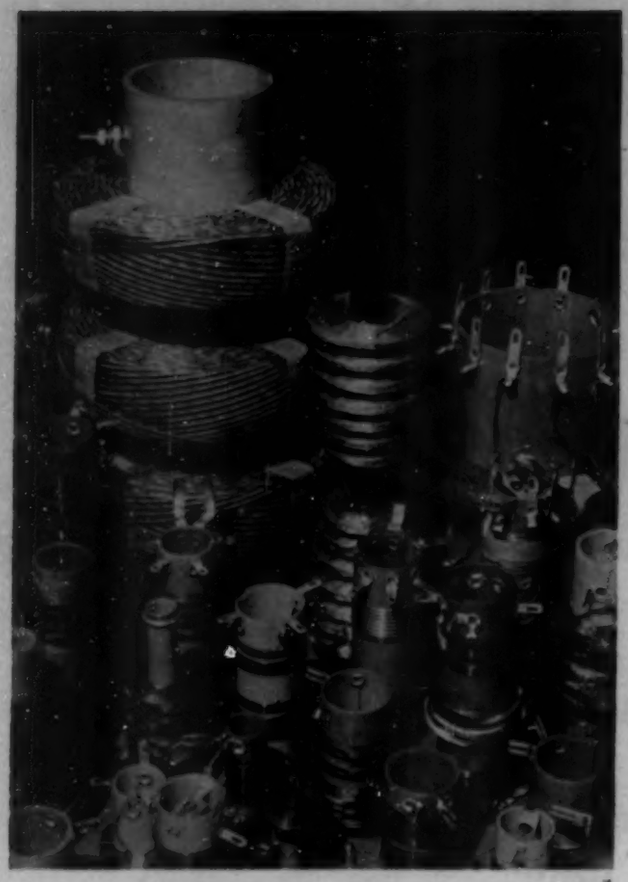

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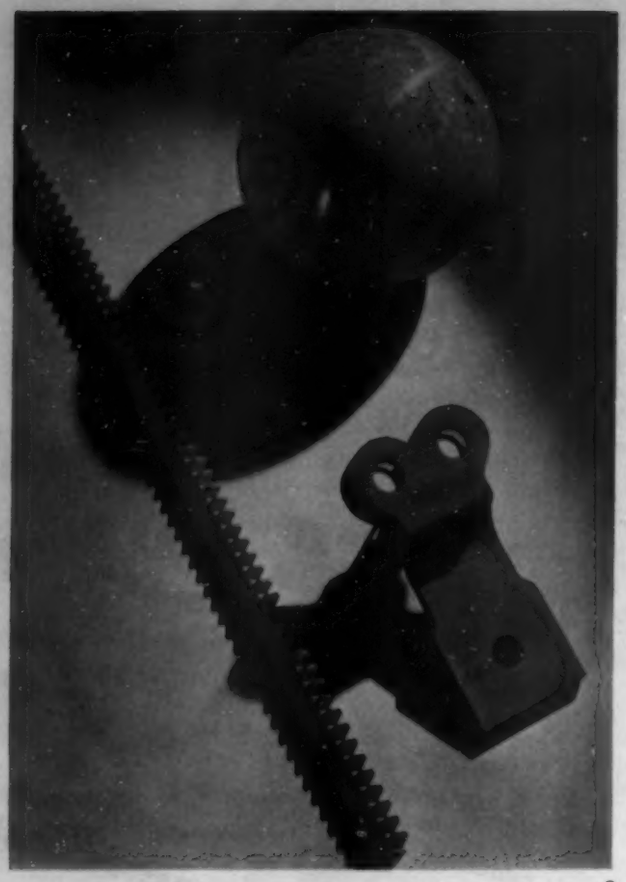

2

(1) Coils, wound on laminated Textolite coil forms, are used extensively in the radio industry. (2) Molded-laminated valve seat ball; sawed and milled rack; sawed, drilled and milled joint; and (3) milled, drilled and turned variometer stator mounting; turned high-tension insulator; milled and drilled spacing strip—all laminated with phenolic resins by Synthane Corporation

3

tribute to many of the properties that make such structures practical for use, such as dielectric strength, power factor, dielectric constant, shock resistance, flexibility, rigidity, moisture absorption, coefficient of friction and wear resistance, machinability, and many other properties. Naturally, as with all other compositions, the optimum of all the properties cannot be obtained in any single compound. Certain properties must be sacrificed in order to obtain others, but by constant research and development, many of these "optimum" cases are being approached to an astounding degree; thus broadening and enlarging the field of plastics beyond its present boundaries.

Phenolic resins were the first to be used to any extent, and they are still the leaders in the field. Since their birth, chemists and physists have studied their structure, and have tried to explain their reactions. The complexity of these resins has, however, veiled these reactions in a coat of mystery. In spite of such a handicap, the chemist has been able to make phenolic resins obey his command with surprising accuracy, and has been able to see through the veil sufficiently to predict new structures that have enabled the industry to advance at a rapid rate. Phenolic resins have two, seemingly inherent, faults that the chemist has not succeeded in totally overcoming. One is the low arc resistance of

Quieter, smoother-running because of

FORMICA GEARS

Formica pinions on motors have made electrically driven equipment much quieter, and Formica gears at important points in the machine, have absorbed noise and shock to produce greater durability and smoother operation.

This improvement is a selling force of importance to the machinery manufacturer, and a great help to the maintenance man. Hence the growing number of machines on which Formica gears are standard equipment, and the increasing use of Formica for replacement purposes.

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Foote Gear Works
Cicero, Ill.
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Clarksville Foundry & Machine Co.
Clarksville, Tenn.
The Horsburgh & Scott Co.
Cleveland, O.
The Stahl Gear & Machine Co., Cleveland, O.
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Hoell Machine Co.
Green Bay, Wis.
Hartford Special Mchny. Co.
Hartford, Conn.
Beaty Machine Works
Keokuk, Ia.
The Generating Gear Co.
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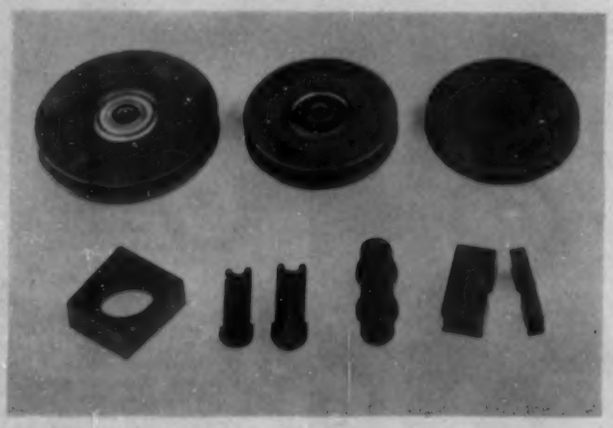
Badger State Gear Co.
Milwaukee, Wis.
Precision Machine Co.
Milwaukee, Wis.
E. A. Pyach Co.
Minneapolis, Minn.
Joaquin Alemany Lopez
Havana, Cuba
Kennedy & Bowder
Nashville, Tenn.
Natisch Gear Works
Brooklyn, N. Y.
New Jersey Gear & Mfg. Co.
Newark, N. J.
Prager, Inc.
New Orleans, La.
J. Morrison Gilmour
New York City
Sier-Bath, Inc.
New York City, N. Y.
Mid-State Electrical Engineering Co.
Osceola Mills, Pa.
Puritan Machine Co.
Omaha, Neb.
E. M. Smith Machine Co.
Peoria, Ill.
The Eagle Gear & Mch. Co.
Philadelphia, Pa.
Rodney Davis and Sons
Philadelphia, Pa.
The Pittsburgh Machine & Supply Co., Pittsburgh, Pa.
Perkins Machine & Gear Co.
Springfield, Mass.
Winfield H. Smith, Inc.
Springville, N. Y.
Alling Lander Company
Sodus, N. Y.
Charles E. Crofoot Gear Corp'n, South Easton, Mass
Arlington Machine Co.
St. Paul, Minn.
Farwell Mfg. Co.
Toledo, Ohio
Diefendorf Gear Corp.
Syracuse, N. Y.
Batson Cook Co.
West Point, Ga.
Worcester Gear Works
Worcester, Mass.
Massachusetts Gear & Tool Co., Woburn, Mass.

the material which causes carbonization of the resin very readily in contact with an electric arc, and even in the presence of corona. The other is darkening of the resin in the presence of ultraviolet light, which limits its use for decorative purposes. Light colored phenolic resins have been used but eventually turn dark on exposure to ultraviolet rays.

The research and development behind the chemist has given him the knowledge and the tools with which to select and guide his work in developing specific procedure. For example, his work has revealed to him that certain ratios of phenol and formaldehyde when reacted in a certain manner will give a product having a very fast cure, and a very rigid product. In some cases the product can be pulled from the mold or press without cooling. The product, if the proper type of catalyst has been selected, will have excellent electrical properties. However, if a more flexible product is desired, a modified phenol or cresol can be used. This cresol is usually in the form of a mixture of ortho-, meta- and para-cresols, and may contain some xylenol, the proportions of each depending on the degree of flexibility that is desired, together with what other properties may be needed. Meta-cresol is known to be fast curing. Ortho-cresol is known to be slow in cure, but offers a greater degree of flexibility. All in all, the chemist has an infinite number of combinations that he can make, to say nothing of the variations that are possible by the proper selection of catalyst, activators, and cooking procedure.

The limitations mentioned above for the phenolic resins have aided in the advancement of the urea-formaldehyde resins in the laminating industry. Although they are inherently more brittle than phenolics, they have much greater permanence of color, are affected less by ultraviolet light, and have an arc resistance of a high order. It is easy to see why the urea resins have been so popular in the decorative field; particularly in the light colors and pastel shades. They have also found some



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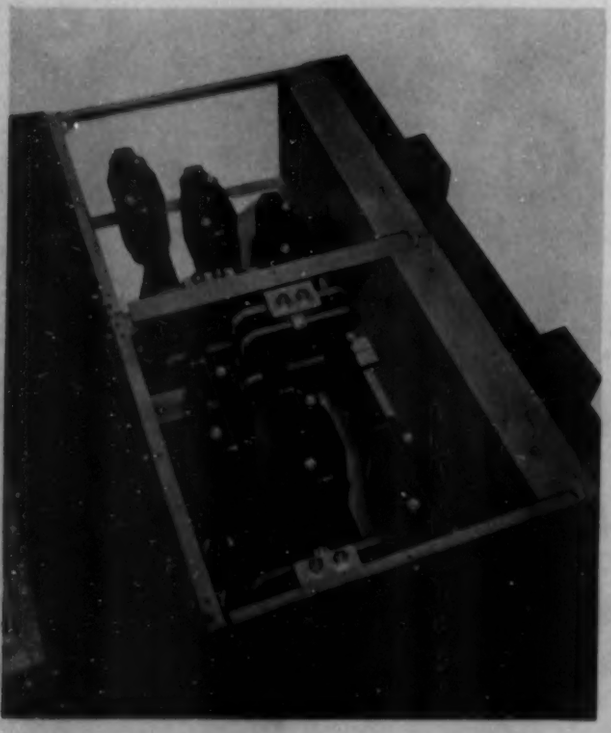

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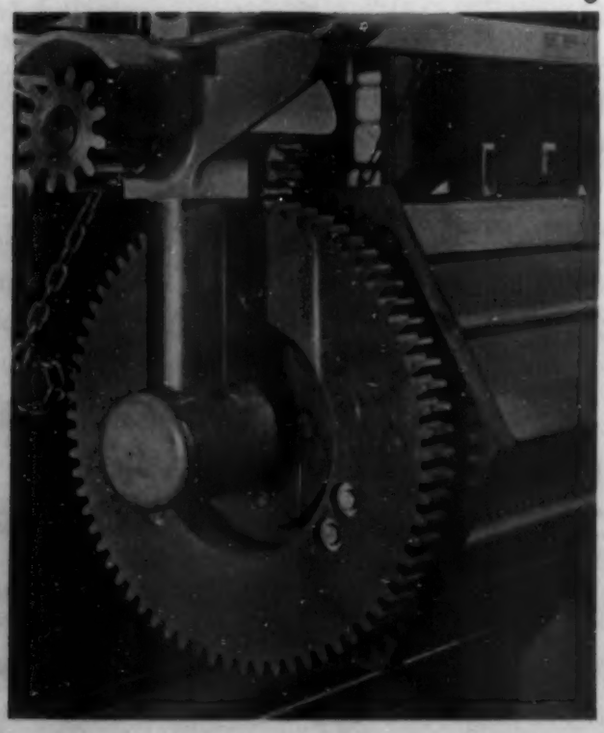

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(4) Laminated Formica airplane pulleys and fairlead bushings operate quietly and give long-lasting service. (5) Delta Star Co. uses Formica insulating material for bus bars in a switch gear assembly and finds that it withstands short circuit stress up to the capacity of the breaker and sometimes over. (6) Because of its chemical resistance to acid solutions and electrical insulating properties Formica is chosen by Crown Rheostat & Supply Co. for its 16-in. diameter, 2-in. face gear used on industrial plating equipment

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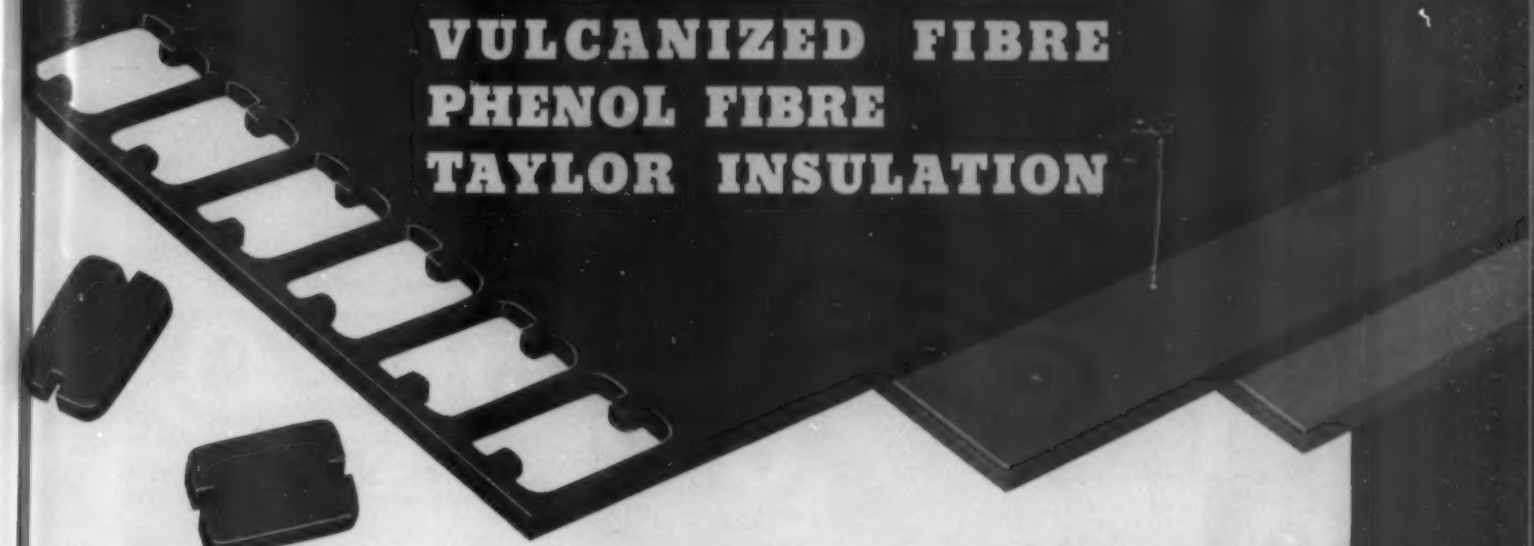

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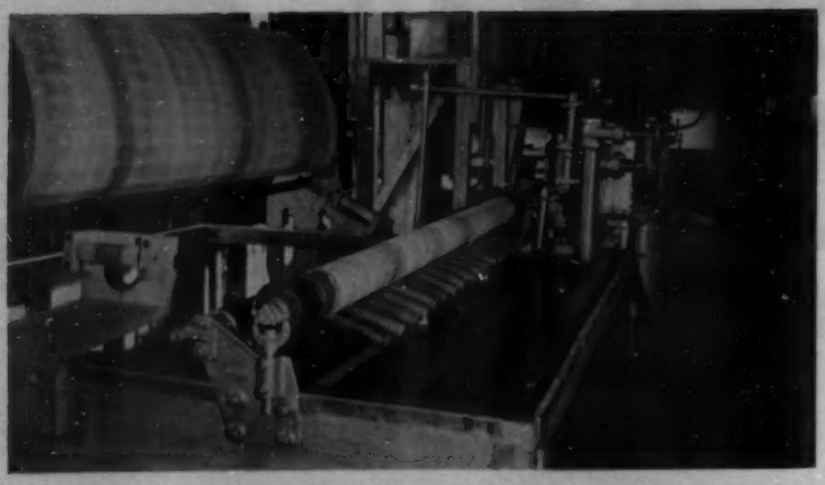
SHEETS
RODS
TUBES
FABRICATED PARTS



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(7) Phenolite washer pegs installed on a dye beck in the plant of Joseph Bancroft & Sons, will not splinter and cause cloth to be damaged as did the wood pegs formerly employed. (8) In the same plant, tenter rails or top casings on a tenter frame are of asbestos base Phenolite. On this particular frame, the life of wood top casings was six weeks—the laminated plastic version lasts approximately five years, wear on the chain is reduced and higher speed is possible

application in the electrical industry for arc barriers and arc shutes when arc resistance is of prime importance. So far the ability to obtain the flexibility and mechanical properties of the phenolic has not been attained, and their higher cost has held back their more general use in industrial applications.

The use of thermoplastic resins in the industrial laminated field has not made much headway. This is due principally to the difficulty in getting impregnation of the fiber structure to an extent sufficient to obtain the desired moisture resistance and to the inherent cold flow properties of this class of resins. The principal reason for lack of penetration or impregnation is the large size of molecule that make thermoplastic resins what they are, and even though some could be put into the fillers in their monomeric state, there are difficulties in subsequent polymerization that have hindered their use.

Applications

For many years it has been the chemists' fondest dream to develop a resin "as strong as steel, as flexible as rubber, and as clear as glass," but, alas, he must be satisfied with a feeble approach. Such is the case with a laminated product coated with rubber. A rubber surface is desired, but also a rigid structure or core is needed to supply the "body." The development engineer was versatile enough to see this and a new product is now available to the industry. In another case, the arc resisting properties of vulcanized fiber were desired, but it was also important to elimate the warpage that inherently goes with fiber. Here again the versatility of the engineer combined a fiber face on to a phenolic laminated core, and produced a product that now finds wide application for arc resistant barriers and arc shutes, as well as other electrical uses.

In addition to the many grades of flat sheet materials that are made, tubes and rods play an important role. In general, tubes are either rolled on a mandrel, and subsequently cured in ovens on the mandrels, or the impregnated material is wound on a mandrel, and then placed in a mold to be subjected to heat and pressure. Their chief application is as insulation barriers, and as radio coil forms. In coil form applications, many properties are desired such as good dielectric strength, low loss factor as received, and after prolonged exposure to high humidity conditions—such as may be encountered in the tropics—good machinability where threads must be cut on the surface as fine as 100 threads to the inch. It must also be flexible and tough enough to withstand the punching of many and various sizes and shapes of holes in the tube. All this taxes the chemist and the engineer to their utmost, to get the most out of the resin, select the

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Stocked for Immediate Shipment in Thickness from 1/100" to 1/28" in the Following Woods

AVODIRE—
A popular blond wood, imported from the French Ivory Coast of Africa

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Also a blond wood of uniform texture from Guatemala

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This wood with its rich golden shade comes from Africa

WHITE BIRCH—
A blond American wood that provides beauty, strength and even texture

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The New England sugar maple with its hard and dense grain offers a fifth choice of blond woods

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Genuine mahogany from Mexico and Africa in pink and dark red brown shades

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Genuine Southern quartered red gum provides beautiful graining

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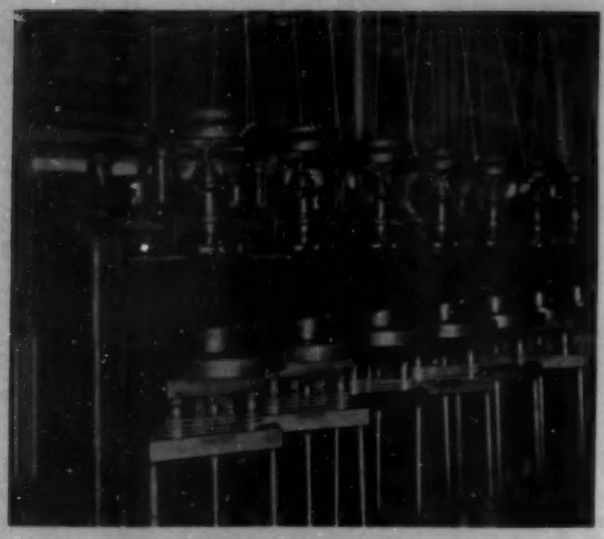
This American wood is evenly colored and its dark rich tones are always popular

RED BIRCH—
The red heart of the American birch provides unusual soft effects

Flitches of all the woods are carefully selected for uniform figure and fine texture. Because they are always carried in stock, the Parkwood Corporation can offer these imported and domestic veneers for immediate shipment.

For the first time, manufacturers of laminated plastics can buy these veneers especially prepared for their particular use. Samples of any of these wood veneers are available upon request. For samples and complete information write the PARKWOOD CORPORATION, LEOMINSTER, MASS.

PARKWOOD CORPORATION



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(9) Brownell twister flyer bushings of Micarta. Unlike wood, laminated plastic flyer bushings cannot dry out, crack or cut stem on expensive stem gear assembly. Micarta bushings in service for more than two years are said to show no sign of wear. Friction is reduced and lint collection eliminated. (10) Laminated Textolite retainer rings for ball bearings are sturdy and durable

proper type of thin paper, and govern the process to the extent of coming out with a product that will satisfy all concerned. The base materials may be either paper, cotton cloth, asbestos paper, and asbestos woven fabric, and applied to machines as rollers, mandrels, and the like, as well as for the insulation of giant transformers. The diameters and wall thicknesses of tubes cover a wide range. Tubes may vary from $^1/_8$ in. in diameter and 24 in. long to 6 ft. in diameter and 8 ft. long. The wall thicknesses may vary from .008 in. to several inches.

Of the various mechanical applications, gears are one of the most important. The selection of the ingredients, and their processing for gears, must be such that the product will be resilient enough to give quietness, and yet have a hardness that will give long wearing qualities. It must also machine to a fine finish, and not be affected by the heat of the lubricant, which may become very high in an internal combustion engine. In a similar category comes ball bearing separators, that must machine to a smooth, glossy, highly resistant to wear, surface finish. The laminated plastics separator has made practical ball bearings for applications where the shaft may turn as fast as 50,000 r. p. m.

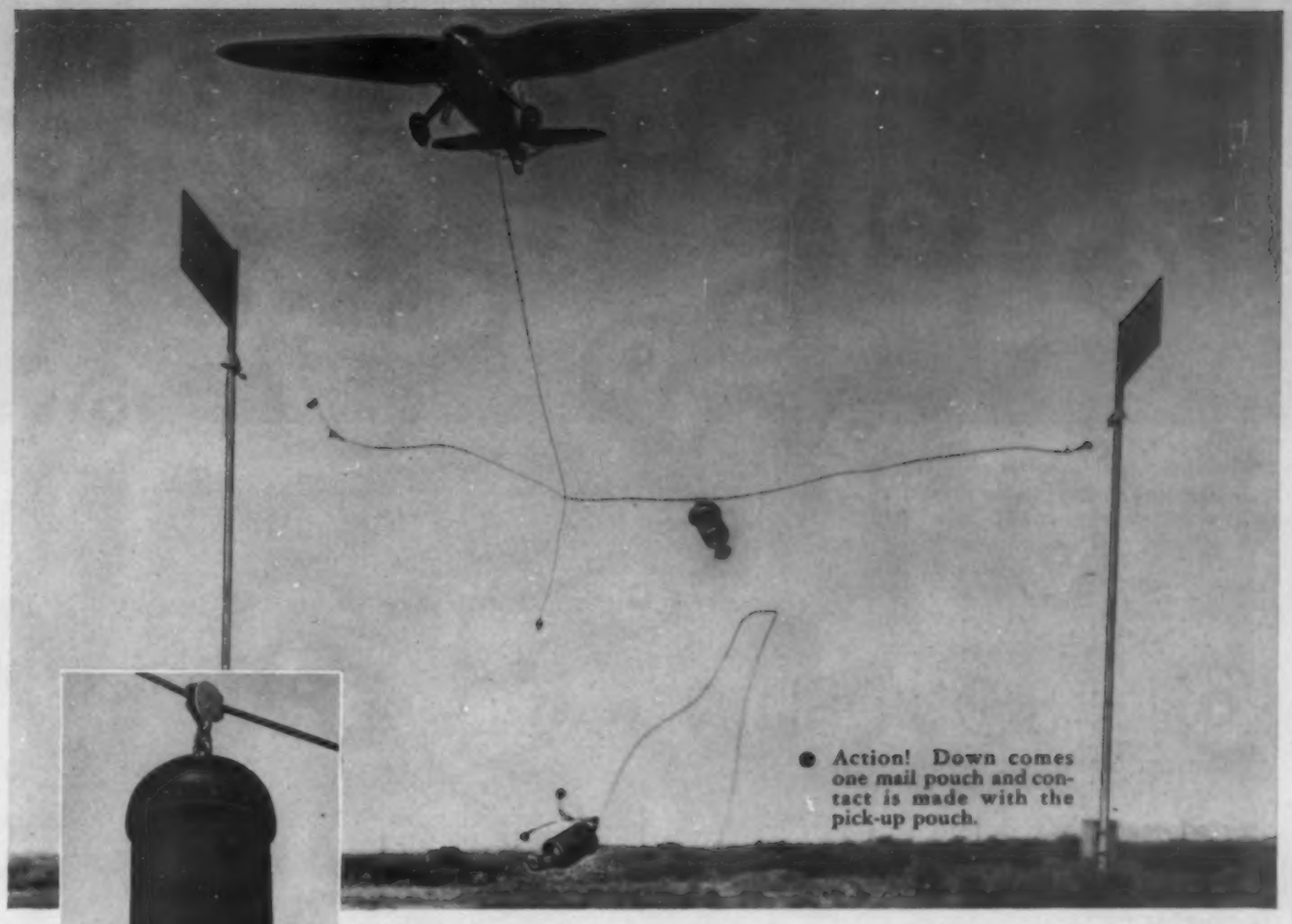
Cloth base laminates combined with the proper proportion of graphite to give a certain degree of lubricity, together with the smoothest possible finish, and yet not too much to injure the bond strength, offers a compound that is unsurpassable for many applications. It can be used for gears where lubrication is impossible or scanty, and is particularly effective in worm gears where a sliding action is always present. It can be used as a bearing with oil, water, or grease lubrication, but above all it is most admirably suited for cams, and has been shown to outlive and outwear all other types of cams. This cam life, particularly on fast moving equipment, has outlived such materials as cast iron, hardened steel, and alloys of various descriptions. It has astonished the experts, and has become an indispensable part in speeding up and increasing the life of certain machines that operate continuously at a rapid pace.

The use of roll neck bearings made of laminated plastics of the phenolic type has been an outstanding development. These bearings use water as lubrication; which is ideal for steel and brass rolling mills, as well as paper mills, since water for cooling is necessary on the rolling mills and is present in paper mills from the nature of the process. Here the fabric and resin must be chosen with the utmost care to insure low coefficient of friction, and to withstand the wear and loadings up to 5000 lbs. per sq. in. as well as to withstand the shock and impact that generally accompanies such applications. This is one of the applications for a heavy weight fabric base, in order to get the maximum impact resistance.

Molded laminated shapes and forms hold a wealth of promise. Several years ago we had the miner's helmet, and then the cafeteria tray. Since then have come the Autobridge, paper cutter bases, boxes of various shapes, refrigerator inner doors, table tops, etc. It is only a matter of time until this line is expanded to include all types of furniture such as desks, chairs, tables, drawers, cabinets, and who knows what else. The chief drawback to molded laminated forms is the necessary draft required on the vertical edges. At present it is desirable to have a 5 deg. to 7 deg. draft. No doubt this objection might be turned into an asset by proper design.

Trade names

Aqualite, Duraloy, Formica, Insurock, Lamicoid, Micarta, Phenolite, Spauldite, Synthane, Taylor, Textolite.



● Action! Down comes one mail pouch and contact is made with the pick-up pouch.

The Skymail pouch, with National Fibre cap riveted to the rubber apron to which the inner canvas bag is attached, suspended on the cross line, waiting for the pick-up.

Seventy-six times a day this National Fibre capped Skymail pouch is dropped 40 feet from a 100 mile-an-hour traveling plane. Plenty of proof that National Fibre is tough.

NATIONAL VULCANIZED FIBRE

Takes it on the Nose!

. . . Cutting Costs for All-American Aviation, Inc.

Above is a picture of National Fibre being put to one of today's toughest tests. A specially constructed U. S. Mail pouch weighing 30 pounds with contents, *capped with National Fibre,* is dropped 40 feet above the earth from a plane sweeping down at a 100 mile-an-hour clip. This happens *76 times a day,* six days a week, in Pennsylvania, Delaware, Ohio and West Virginia, the circuit of the new skymail "drop and pick-up" system operated by All-American Aviation, Inc.

As a protective nose for the pouch, several materials were tried . . . and rejected. Steel dented. Wood chipped and splintered. Rubber, if made strong enough, was too heavy. Canvas would not streamline. Then National Fibre was tried . . . and proved to be exactly the right material. It possessed the required qualities: lightness, ability to streamline but, most important — great impact strength.

Since May 12th, these pouches have struck their National Fibre caps against the ground (impact equalling 11,200 foot pounds) thousands of times WITHOUT A SINGLE REPLACEMENT.

There may be some place in your production set-up or the construction of your product that calls for an inexpensive, light, tough, oil-resistant material with high dielectric strength. This is where you can *profitably* use National Fibre.

Tell us your problem. Our consulting technicians will gladly work with your engineers. A letter, call or wire will bring prompt action. There is no obligation, of course.

NATIONAL VULCANIZED FIBRE COMPANY

FOUNDED 1873

WILMINGTON DELAWARE

NATIONAL VULCANIZED FIBRE

PHENOLITE Laminated BAKELITE

These NATIONAL Products have a Cost-Cutting Application in your field. We can make it easy for you to select the right product and grade.

Laminated panels of low-resin content are produced by heat-curing an assembly of alternate layers of resin and wood veneer. Panels at American Furniture Co. (above left) are bonded with Tego and a series of assemblies, placed in a multi-platen hot press, is cured in a few minutes' time. Workmen at Smith Wood Products, Inc. (above right) spread fir veneers with Uformite liquid resin

RESIN-BONDED WOOD

by R. KOCH*

SINCE THE TECHNICAL STATUS OF SYNTHETIC resins in the wood industry was reviewed here last year, some of the developments then foreseen have been practically realized. These developments have been of a commerical rather than technical nature. For although activity in technical research continues to increase, the requirements of efficient production have already been well met by the available equipment and resins, in film and liquid form.

Principal resin types

To summarize briefly, the commercial production of resin-wood combinations—in the form of plywood—is now in its sixth year in this country. Technically the product may be considered as a laminated panel of low-resin content, produced by the heat-curing of an assembly of alternate layers of resin and wood veneer, the resin being partly absorbed by the latter.

For this process, the longest and highest-quality service has been obtained from a phenolic resin in film form. It may be regarded as the most ideal wood-bonding agent known to date. Phenolic resins in solution have had rather limited, specialized applications, but the results obtained have been excellent. Urea-formaldehyde solutions are the newest type in practical use, but because of their economical features, they have developed the largest volume of use, within two years.

The phenolic film is generally called for wherever assured highest quality of panel is required: it offers extreme durability, cleanliness, uniformity, and adaptability, at the lowest possible unit cost for these qualities. Phenolic resin solutions also develop high durability, and are being used where the liquid-spreading operation is found to be more practicable for obtaining this characteristic.

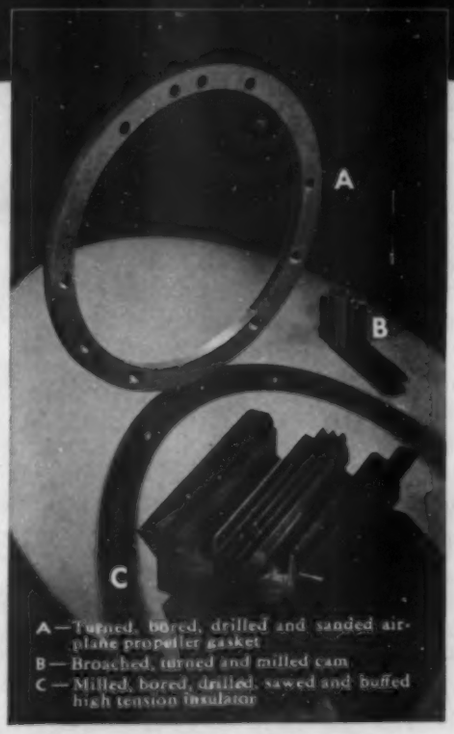
Urea-formaldehyde resins have the particular virtue of allowing extension with flour and water to almost any desirable unit cost. They are never as durable as the phenolic type, and addition of flour successively reduces their waterproofness. But in any practical concentration they are much more durable than any of the traditional "glues" used in plywood.

All the resins employed for quantity production of wood panels today are of the heat-curing type. For this purpose the industry is using a multi-platen hot press which cures a series of assemblies in a matter of minutes. On one standard type of press in general use, the output can be maintained at over 1500 sq. ft. of plywood an hour for a five-ply panel. Depending on the nature of the assembly, the press capacity, and other factors, the output may be even greater, if needed. But in any case, the heat-curing resins have reduced the "glueing" time and operation to such a minimum that older adhesives can scarcely outweigh this advantage even with lower initial price.

Resins that cure without being heated have a much more restricted use in wood technology. They can economically be employed only in joints where hot-pressing is quite impractical, as in edge and corner joints, compound lumber blocks, and the like. A cold-setting resin has not only the operating defects of ordinary wet glues, but takes longer to reach its ultimate cure and durability—which never, in fact, reaches that of the heat-

* Resinous Products & Chemical Co.

You can make soap chips or buy them ready-to-use—but..



A—Turned, bored, drilled and sanded airplane propeller gasket
B—Broached, turned and milled cam
C—Milled, bored, drilled, sawed and buffed high tension insulator

. . . *in buying technical plastics, as in buying soap chips, ready-to-use is often more satisfactory*

You could shave your own soap chips, but with many economical, ready-to-use chips on the market, it sometimes isn't worth your time, trouble and expense.

There is a possibility that in your shop, equally valuable time and money may be wasted in fabricating parts that can be bought more profitably from us—and ready-to-use. For two good reasons:

First: Synthane Technical Plastics have many properties *in combination*. Their selection, in place of another material, generally gives you initial advantages in weight reduction, corrosion resistance, machinability, and numerous other physical, chemical, mechanical and electrical characteristics.

Second: You gain—usually—by letting us machine parts for you. You relieve yourself of the responsibility for mistakes in machining, for rejects, and delays in delivery. You benefit from our experience in newer, faster ways of machining Synthane. We make properly the dies, jigs, and fixtures for machining technical plastics. You also save the capital investment in machine tools if the present equipment of your shop is not well suited for the fabrication of Synthane exclusively.

If your production requirements justify the installation and maintenance of special machines then do your own machining. We'll supply your sheets, rods and tubes.

At the left are parts machined from Synthane by us for three widely different manufacturers. We believe you, too, will find Synthane materials and machining well worth looking into. Why not send in your application today?

SHEETS • RODS • TUBES • FABRICATED PARTS • SILENT-STABILIZED BEAR MATERIAL

SYNTHANE CORPORATION, OAKS, PENNSYLVANIA

SYNTHANE

1

2

(1) An impressive building at the Golden Gate Exposition is sheathed with Resnprest, an all-weather, resin-treated plywood. The shiplapped, "V"-grooved panels, 4 ft. by 8 ft. and 7/16 in. thick, are covered with one coat of plastic paint. (2) The California State Building at the same Fair is encased in more than 110,000 sq. ft. of Resnprest exterior plywood

cured resin. Its slow setting, in turn, permits unequal absorption into the wood and attendant uncertainties of result. For plywood operations, therefore, the use of cold-setting resins would represent an expensive and backward step.

Broader markets

Commercial developments in resin-bonded plywood include, foremost, the extension into much broader markets. The flexibility of cost obtainable with the urea-formaldehyde resins, and their high relative durability, have permitted their introduction into various grades of stock panels and into mass-production, inexpensive furniture.

For several years the best grades of furniture have been made with resin film-bonded panels or two-ply veneer faces, to offer the best possible protection against separation and surface checking. Some of the manufacturers ultimately installed hot presses themselves and have, since then, had an increasing business in film-bonded—completely exposure-proof furniture.

However, this has accounted for only a small fraction of the furniture made in this country and only in the past year did such large producing areas as the South and Northwest go into resin-bonding on a large scale, on the basis of the extensible urea-formaldehyde resins. While film-bonded face veneers are ever more widely employed to give maximum quality on the exposed surface, the liquid resin has succeeded in displacing less durable adhesives even in the cheapest of the other parts.

This has probably been the greatest forward step in the technical standards and prestige of the furniture industry in decades. Dealers, who have been little interested in the technical side of furniture, appreciate what resin-bonding means to them. They have not been slow to pass the story along to the public through the medium of advertising.

Of similar significance is the spread of resin-bonding into lower-cost automotive form, and stock panels. In the Northwest, the large Douglas fir industry already has a growing number of hot presses in operation for bonding with various types of liquid resins. This has been a vital factor in the recent elevation of trade standards in the fir industry, which are now supported by rigid association specifications. All Douglas fir plywood is produced by panel plants for outside sale.

In a similar field, cheaper Eastern hardwoods, such as gum, are now resin-bonded into durable, low-cost stock panels, which have some very decided advantages over coniferous plywood. Lately, even pine is being utilized in ply-construction, fabricated in hot presses with liquid resins. These products mean much to the wood industry in its sales to the building trade, which, until the advent of resins, often sacrificed the unique advantages of wood

Here is Lamicoid—

ready to help solve your unusual problems

MECHANICAL STRENGTH

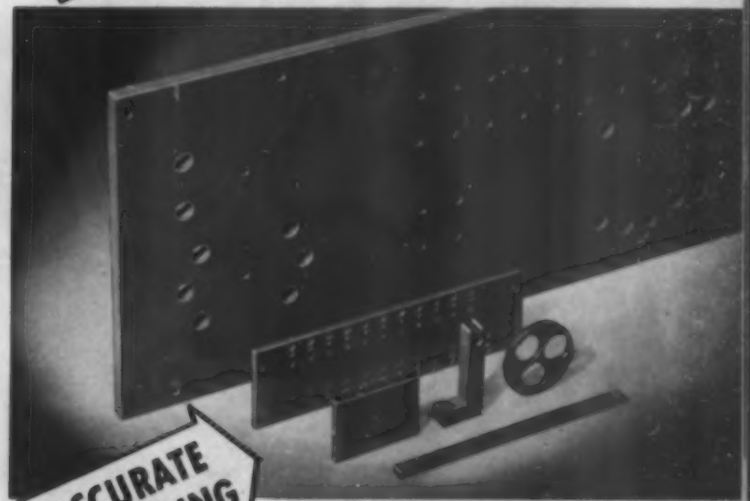
Application of Lamicoid gears extend from small high-speed gears and pinions to the heavy uncut stock shown above for rolling mill and forge-shop machines gears.

DIELECTRIC STRENGTH

These paper-base tubes combine high dielectric strength with the extreme accuracy of machining necessary for radio and television condenser coils.

INTRICATE PUNCHING

Low moisture absorption and low power factor plus micrometer accuracy in these punched parts that hold a smooth, clean-cut edge.



ACCURATE MACHINING

Although these canvas- and paper-base parts are easily cut on a standard drilling or threading machine, dimensions are extremely accurate—do not chip or fracture.

Write for complete information or samples on the wide variety of Lamicoid Laminated Bakelite sheets, rods and tubes for electrical and mechanical applications.

LAMICOID

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MICA INSULATOR COMPANY

200 Varick St., New York; 542 So. Dearborn St., Chicago; 1276 West 3rd St., Cleveland. *Branches at:* Birmingham, Boston, Cincinnati, Los Angeles, San Francisco, Seattle. Canada: Montreal, Toronto.

MICA INSULATOR COMPANY

panels principally because of their uncertain integrity.

The past year has also seen a wider spread of resin-bonded plywood in industries that had already made earlier use of it. These include the radio, air-conditioning, aircraft and automotive industries, among many others. The products of Philco, RCA, Zenith, Chrysler, G-E, Packard, Bellanca—all embody resin-bonded plywood in their construction, to give prolonged service at economical cost. Incidentally, from the standpoint of synthetic resin, there is only a difference in degree between a small radio built of resin-laminated wood and a similar one molded of resin and filler (with simulated wood grain).

A special product based on the combination of synthetic resin and wood, is the multi-ply type of aggregate bonded under higher pressures, sometimes known as "improved wood." The resin can be introduced in the form of liquid or film. The former gives a harder, stiffer product throughout the mass and has certain difficulties of uniform application. The film gives an extremely durable joint between the thin veneers, without impregnating the wood appreciably, which leaves the latter in a tough resilient condition. Both types have seen service for some time in Europe, where raw material conditions favor them, but their specific properties also indicate a wider use in this country.

A certain hardness, toughness, and shock resistance characterize this class of product, as compared with other materials. To some extent it serves as replacement and improvement, as in gear wheels, aircraft struts and propellers, gun stocks, casters and the like. Its cost is relatively high but it is readily machined and usually gives long service. The German Schwartz propeller, which has been rather fully described, is built up of compressed, resin-bonded veneers and its service record over a period of years has been superb. There have been developments along similar lines in the American and British aircraft industries. In the same industry, "improved wood" is also serving in forms for molding light metal sheets, in place of steel dies.

Improved wood, however, is also a promising substitute—or better, improvement—for certain species of solid wood, which are becoming scarce and expensive or have proved inadequate. Such species as dogwood, persimmon, hickory, maple, can readily be surpassed in their best properties by suitable veneer constructions of common woods, offering a uniformity and freedom of design not otherwise obtainable.

Resin-bonding of plywood has brought engineering standards to an industry that long suffered from numerous uncontrollable and immeasurable variables (e. g., moisture distribution, grain direction, etc.). In the past few years it has become the established norm for production that has any regard for quality. In resin-bonded improved wood, the combination of resin and wood veneer has been brought to a technical point where a desired combination of physical properties can be predicted and designed in advance. This represents the best practical utilization of both resin and solid wood fiber, with their many desirable and complementary properties.

3

A G-E unit, room air-conditioner in an executive office in the building of the Air Conditioning Corp. keeps the atmosphere at a comfortable working temperature. The housing, of Tego-bonded plywood, fits in harmoniously with the surrounding furnishings. Panels of the same material are equally efficient and effective on the 1939 Packard station wagon, by Cantrell & Co., for they clean easily and are tough and durable

4

PARKWOOD TEXTOLITE

A NEW PERMANENTLY FINISHED DECORATIVE MATERIAL

A NEW, PERMANENTLY FINISHED DECORATIVE MATERIAL DEVELOPED JOINTLY BY THE PARKWOOD CORPORATION AND THE PLASTICS DEPARTMENT OF THE GENERAL ELECTRIC COMPANY

PARKWOOD TEXTOLITE is the combining of wood and plastics into beautifully finished panels. The Parkwood material is extraordinarily thin wood veneerings, uniform throughout in thickness and texture. These veneers are carefully impregnated with G-E Textolite resins. After treatment these sheets of veneer are cut into strips of varying widths, depending on the weave width desired in the finished panel. The strips are then woven evenly and expertly by hand into the desired pattern or design. The woven sheets of Parkwood are then combined with Textolite and processed under heat and pressure.

The development of Parkwood Textolite provides for your use a material in which beauty and the genuine wood graining are permanently preserved. No matter what type of wood is used—light, dark or a combination of both—the satin-finished surface is hard and durable. Parkwood Textolite not only provides the rich, soft texture achieved so beautifully by the wood craftsmen but it is also impervious to moisture, alcohol, fingernail polish, and most acids and alkalies. These advantages, plus the fact that Parkwood Textolite is highly resistant to cigarette heat and very easy to keep clean, make it truly a modern material.

PARKWOOD TEXTOLITE

USES

Parkwood Textolite is made in two thicknesses—$\frac{1}{16}$-inch thick for veneering to plywood, pressed wood, asbestos board, metal, Masonite and similar backings; 0.020-inch thick (which can also be veneered for use on sharp curves and radii) can be especially fabricated by stitching, stapling, sawing, punching, and cutting with ordinary shears. Because Parkwood Textolite is available in these two thicknesses and because each can be so easily handled with ordinary woodworking processes, its use is most diversified.

For instance, architects, industrial designers, interior decorators, furniture manufacturers, aircraft manufacturers, large display manufacturers, and many others who are responsible today for the better living of tomorrow find Parkwood Textolite a practical material for:

PANELING for public buildings, homes, airplanes, trains, restaurants, elevators, offices, and the like.

INTEGRAL PARTS OF PRODUCTS such as tables, counters, trays, luggage, desks, display cabinets, fine packaging and utility boxes, decorative screens, bars, air conditioning units, etc.

TYPES OF MATERIALS

STANDARD TYPES

Parkwood Textolite is available in three standard weave widths—two-inch, three-inch, and six-inch strips. These weave widths are woven on a diagonal or straight weave pattern and are recommended for general use.

For wood finishes, Parkwood Textolite offers the following in standard weave widths and weaves:

MAHOGANY—Genuine mahogany from Africa, the West Indies and Mexico in light pink or dark red brown. Flitches are carefully selected for beautiful figure and fine texture.

AVODIRE—A golden, creamy, shaded wood imported from the French Ivory Coast of Africa. Because of its dependable, even color it is one of the most popular blond woods which harmonizes well with mahogany.

BIRCH, red and white—This American wood is one of the most important hardwoods of the world because of its beauty, strength, and even texture. The red heart, and white sap wood are carefully separated and woven into effective designs.

MAPLE—The New England sugar maple, with its hard and dense grain offers a choice of blond woods.

WALNUT—This American wood is evenly colored and beautifully grained. Its soft brown tones have always been popular.

SIZES AND THICKNESS

Standard types are available in both the $\frac{1}{16}$-inch and 0.020-inch thicknesses in the following size sheets:

$\frac{1}{16}$-inch Parkwood Textolite sheets in sizes 36 in. by 72 in., 30 in. by 30 in. and 36 in. by 36 in.

0.020-inch Parkwood Textolite sheets in sizes 36 in. by 72 in., 30 in. by 30 in. and 36 in. by 36 in.

All sizes are shipped with the unfinished side sanded, ready for application.

SPECIAL DESIGNS

For small products where narrower weaves, such as $\frac{1}{2}$-inch or 1-inch widths, are more applicable, Parkwood Textolite is available in such weaves on special order.

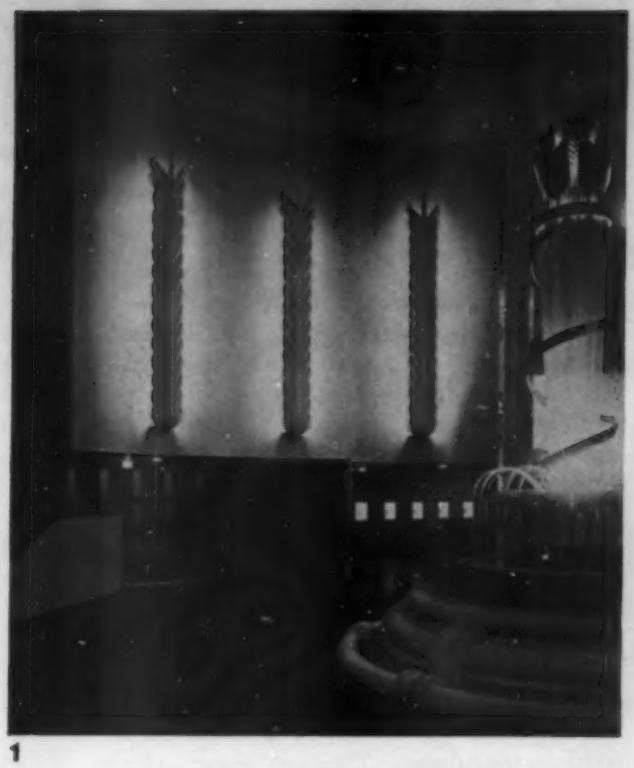
Center designs, made of a combination of different widths of strips either of one wood or in combination with one or more woods, can be made to your own specifications or our styling and designing department will help you.

SAMPLES

So that you can feel and see how beautiful this material really is, we will gladly send a sample upon request. For sample or further information, write the Plastics Department, General Electric Company, One Plastics Ave., Pittsfield, Mass., or the Parkwood Corporation, 24 Water St., Wakefield Mass.

GENERAL ELECTRIC

PD-1092



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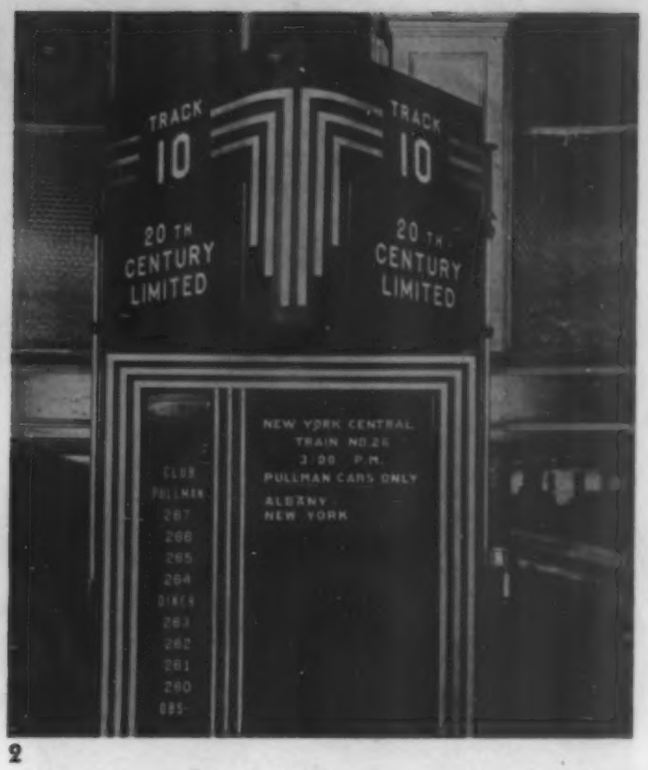


2

In the House of Coty (Fig. 1) at the New York World's Fair, scarlet translucent Lamicoid scallops trim the edges of metal indirect lighting fixtures which extend upward on the rounding wall, in the form of giant leaves. Translucent engraved laminates appear more and more frequently in railway and other directional signs, both for passenger information and advertising purposes. The example pictured (Fig. 2) shows a translucent engraved Lamicoid sign in the La Salle St. Station, Chicago. Concealed lights shining through the engraved sections make them visible from all parts of the station

TRANSLUCENT LAMINATES

by HENRY E. STOCKFISH*

TRANSLUCENT LAMINATES OWE THEIR EXISTENCE to the well-known property of formaldehyde to react with either phenol or urea to form a complex resin end-product which is insoluble and permanently infusible. If the reaction is permitted to progress only in part there results a melt which, when dissolved in an added solvent, can be utilized as an impregnating solution with paper or cloth.

Chemistry of their formation

For translucent laminates, we are interested only in the reactions which yield clear, water-white resins. Phenol-formaldehyde resin is perhaps the most widely known but, paradoxically, its reaction mechanism is not clearly understood, although a good deal of the literature is devoted to the complex reactions.

Briefly, the correct proportions of refined phenol and formaldehyde, treated under carefully controlled conditions in suitable vessels free of iron parts, will result in a colorless concentrated syrup of 60 percent, and upwards, of solids. The urea-formaldehyde mechanism also is not clearly understood. Many investigators seem agreed on certain reactions, as follows:

$$CH_2O + \underset{\underset{NH_2}{|}}{\overset{\overset{NH_2}{|}}{C{=}O}} \longrightarrow \underset{\underset{NH_2}{|}}{\overset{\overset{NHCH_2OH}{|}}{C{=}O}}$$

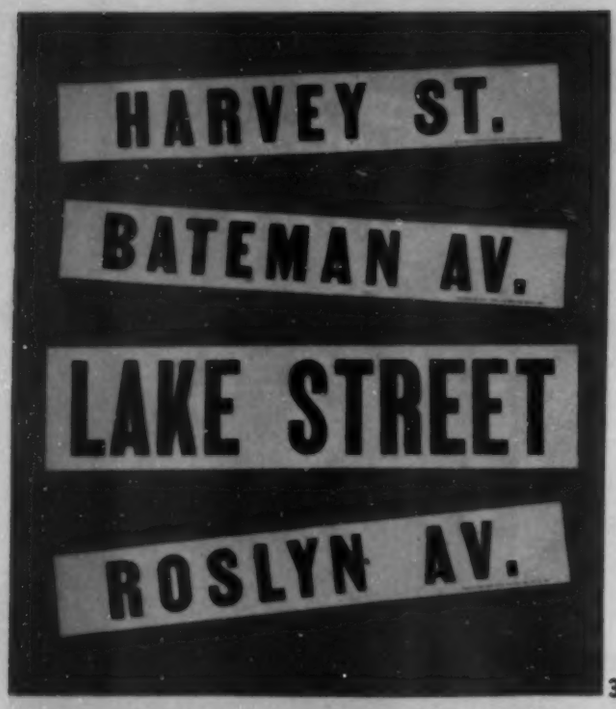
FORMALDEHYDE 1 mole — *UREA* 1 mole — *MONOMETHYLOLUREA*

With excess formaldehyde dimethylolurea is formed:

$$2CH_2O + \underset{\underset{NH_2}{|}}{\overset{\overset{NH_2}{|}}{C{=}O}} \longrightarrow \underset{\underset{NHCH_2OH}{|}}{\overset{\overset{NHCH_2OH}{|}}{C{=}O}}$$

2 moles — 1 mole *DIMETHYLOLUREA*

* Mica Insulator Co.



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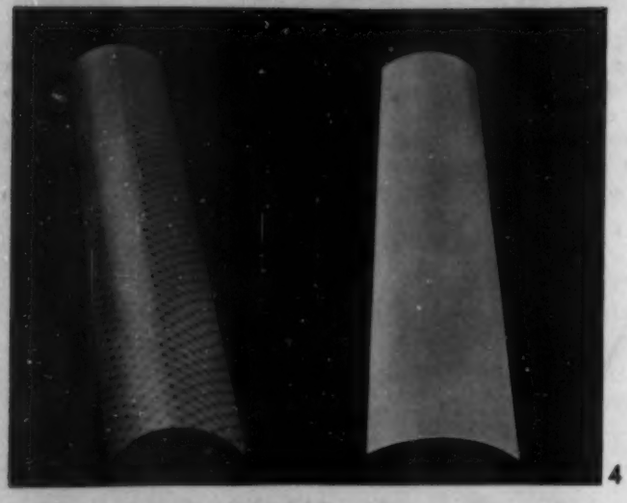
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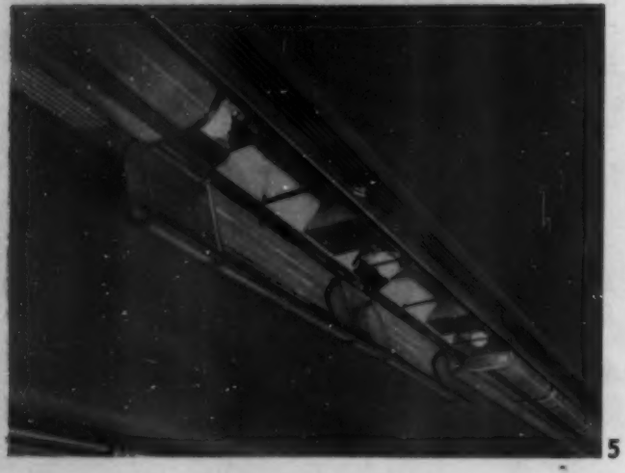
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The influence of hydrogen-ion concentration, temperature, choice of solvent, and time of contact are all factors affecting the complexity of the end-products of the reaction which is manifested by the workability range of the resin. A colorless soluble melt is obtained as in the case of the phenolic resin.

General characteristics

Translucency, flexibility, color, and general workability are prime considerations in the choice of a resin to utilize for lamination, and experience has indicated that the phenolic type is the most useful. It is true that the phenolic colorless type suffers from long exposure to ordinary light and tends to darken slightly, but when colored plates are desired this characteristic has no particular disadvantage.

The urea resin is chiefly valuable for its greater translucence and for its ability to retain most of its original colorless quality, which permits the transmitted light to be somewhat whiter.

Processing

Impregnation of paper is carried out in conventional coating equipment which, by means of hot air currents, removes the solvent. The coated paper is sheeted, placed between stainless steel plates, which impart their finish, and heated at approximately 135 deg. C (to complete the reaction), while compressed to 1000 lbs. per sq. in. Cooling, followed by unloading, yields white plates, translucent and ready for use.

Colored laminated plate is obtained by dyeing the impregnating resin solution. Printed paper may be placed under the surface sheets to produce durable and attractive charts and pictures which are incorporated in the sheet and which cannot be erased. Colored printing inks may be used to heighten the effect for any special decorative purposes.

Properties

Translucent laminates contain many desirable properties which have opened up a wide field for the material in applications where heat softening materials and glass were formerly used. The excellent mechanical strength allows the use of thinner sheets thus permitting lighter weight designs. The coefficient of expansion is comparable to other types of laminated phenolic products and moisture absorption after 24 hrs. immersion is under 5 percent.

Translucent laminates, being thermohardening plastics, are conceded to be more brittle than the thermoplastic type of material. The sheets are sufficiently flexible to bend cold into small radii in the lesser thicknesses and when heated to approximately 250 deg. F. to 300 deg. F. can be formed in simple shapes such as cylinders, half cylinders, S curves, etc. (*Please turn to next page*)

Street signs with black, clean cut letters against white (Fig. 3) are easily seen and read even from a distance. Richardson Co. makes them of translucent Beetle laminated material. Formed sections for trough and fluorescent lighting fixtures (Fig. 4) are produced by General Electric Co. from Beetle resins. Each section of the translucent Beetle laminated lighting fixtures (Fig. 5), installed in streamlined Pennsylvania Railroad trains, opens conveniently for cleaning and replacing lamps

For Better
SATURATING PAPERS
Used in Laminating

TRANSLUCENT PLATE
WHITE OPAQUE PLATE
COLORED OPAQUE PLATE
ELECTRICAL PLATE
QUALITY TUBES

Phone or write HURLBUT at South Lee, Mass. — specialists in manufacturing the highest grade plastics saturating papers — for complete data.

HURLBUT Papers will bring your finished work the utmost in strength, fine finish, hardness and dielectric qualities. Our papers are noted particularly for uniformity, cleanliness and clear formation.

Full information and advice — including sample sheets — are yours for your particular problems if you will communicate with

HURLBUT
PAPER CO.
South Lee, Mass.

SPECIALISTS
IN
SYNTHETIC RESINS

For over fifteen years, the Resinous Products and Chemical Company has specialized in one thing—synthetic resins. This specialization, supported by a continuous program of research, has enabled us to anticipate the needs of industry by introducing today the resins of tomorrow. Among the many fields in which we have pioneered, the following are particularly significant:

In the paint, varnish and lacquer industry—Amberol (phenol formaldehyde), Paraplex and Duraplex (alkyd), Aquaplex (resin emulsion), Uformite (urea formaldehyde), and Acryloid (acrylic ester).

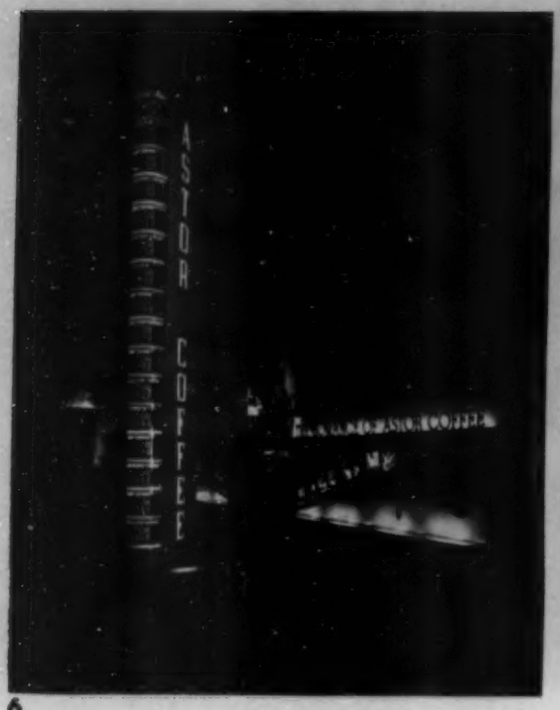
In the laminating industry—Uformite (urea formaldehyde molding solutions).

In the plywood industry—Tego Film and Uformite 430 (resinous adhesives).

In the plastics industry—Dibutyl Sebacate (unique chemical plasticizer for vinyl and acrylate type resins, synthetic rubbers, cellulose esters, etc.).

The Resinous Products and Chemical Company, Inc., Philadelphia, Pa.

RESINOUS PRODUCTS



6

7

The Astor Coffee Exhibit in the Food Building North at the New York World's Fair (Fig. 6) is dramatized by an illuminated column of coffee cans made of translucent silk screened Lamicoid, by Gardner Displays. General Electric Co.'s theme symbol in front of its building at the Fair—a 125-foot stainless steel lightning bolt—is lighted at night through oval strips of white translucent Textolite laminated material

Further, it may be noted that these laminates are:

1. Uniform in translucency and coloring
2. Non-inflammable and heat-resistant
3. Non-shatterable
4. Resistant to warping or shrinking
5. Easily machined and punched

Applications

Translucent laminates have a large and constantly increasing number of applications for decorative, lighting, and utilitarian purposes in the advertising, merchandising, electrical, and industrial fields. They are particularly applicable to lighting fixtures, signs, displays, and illuminated architecture.

One of the outstanding applications during the past year was the development of Venetian blinds—the translucent strips being formed into an S-shaped slat which permits the use of thin material affording extremely compact nesting and allowing the maximum in light diffusion and ventilation. The natural light is diffused through the material providing a beautiful effect.

Translucent laminates when first introduced were principally used for radio dials. Since that time manufacturers of instruments requiring dials in other fields have adopted this type of material principally because of its inertness and non-corrosive properties. Plastic dials have replaced metal in many applications involving adverse atmospheric conditions, chiefly because of the non-corrosive properties of the material. Sheets or pieces of varying thicknesses (.010 to 0.063 in. being those in most common use) in dimensions up to 36 in. by 42 in. formed into ovals, cylinders, half-rounds or flats, permit uses that would be impractical with other materials. Applications utilizing silk screen or rubber plate printing directly on the translucent plate produce extraordinary effects for illuminated advertising displays.

A new and expanding commercial field has been opened by the introduction of a sheet in which the body of the laminate is opacified, retaining the translucent surfaces under which any sort of printed graphic matter may be permanently embodied.

Typical applications

Rear illuminated signs
Lighting fixtures and displays
Lamp shades
Instrument and other dials
Translucent Venetian blinds
Architectural lighting

Exhibitors and concessionaires at the New York World's Fair and the Golden Gate International Exposition have made extensive use of translucent laminates for advertising, architectural, and lighting purposes.

Trade names

Dilecto, *Formica*, *Insurok*, *Lamicoid*, *Micarta*, *Textolite*

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NUMBER ONE

PLASTICS AVENUE

WHERE COMPLETE PLASTIC FACILITIES ARE AT YOUR SERVICE

TURN TO PAGES 201 TO 216 FOR INFORMATION ON TEXTOLITE LAMINATED MATERIALS AND OTHER GENERAL ELECTRIC PLASTIC PRODUCTS AND SERVICES.

Textolite compression molded • Textolite injection molded • Textolite lighting specialties • Textolite cold-molded • Textolite molded-laminated • Textolite laminated

Parkwood Textolite

GENERAL ELECTRIC

PD-1094

NOMENCLATURE

by CARLETON ELLIS

Aminoplast—General terms for synthetic resins from amino or amido compounds. A typical example is urea-formaldehyde resin.

Amorphous—Devoid of crystalline structure.

Asphalt—A dark-colored, viscous to solid hydrocarbon complex including: (a) The easily fusible bitumens often associated with a mineral matrix, not having a waxy luster or unctuous feel; (b) fusible residuums obtained from the distillation, oxidation, etc., of bitumens.

A-Stage resins—Thermosetting resins reacted only to the initial stage where they are soluble and fusible. The normal stage of a resin used for impregnation.

Balsams—Natural vegetable exudations consisting of resins mixed with volatile oil. The name is also applied to products having the physical characteristics of the natural balsams but produced by reactions which normally lead to resinous materials.

Bitumen—A naturally occurring or pyrogenous hydrocarbon complex insoluble in water but soluble in carbon disulphide. Color and hardness variable.

B-Stage resins—Thermosetting resins reacted to a stage where they soften when heated and swell in contact with liquids but do not entirely fuse or dissolve. This is the preferred stage for the resin in molding compositions.

Bulk factor—The ratio by volume of the loose molding powder to the resultant finished article.

Cold flow—Change of dimensions or distortion caused by sustained application of a force greater than the elastic limit.

Cold molding—A procedure in which a composition is shaped at ordinary temperatures and hardened by subsequent baking.

Colloid—Any substance when dispersed into particles whose size ranges between 5 and 100 millimicrons. Molecules of many synthetic resins fall within this range.

Condensation—A chemical reaction in which two or more molecules combine with separation of water or some other simple substance. Applied to synthetic resins it means the formation of a resin by combination of a number of molecules with elimination of water, ammonia, hydrogen chloride or other simple substance. Examples of condensation resins are alkyd, phenol-aldehyde and urea-formaldehyde resins. The final products are also called condensation-polymers. *See Polymerization.*

Co-polymerization—The term applied when two or more substances polymerize at the same time to yield a product which is not a mixture of separate polymers but a complex having properties different from either polymer alone. Thus, Vinylite copolymer is produced by polymerization of a mixture of vinyl acetate and vinyl chloride.

C-Stage resins—Thermosetting resins in the final stage in which they are infusible and insoluble. The state of the resin in the final molded article.

Curing—The change of a binder from the soluble-fusible condition to the substantially insoluble-infusible form by chemical action. The heat-setting of a resinoid. Action is analogous to vulcanization of rubber.

Dielectric strength—Voltage gradient at which a continuous electrical discharge will take place between two electrodes when the material in question is placed between the electrodes and a potential difference is applied to them.

Elastic deformation—One in which a substance reverts to its original dimensions on release of an applied stress.

Elastic limit—The point at which a body begins to yield under a stress; that is, when the stress is equal to or greater than the internal friction.

Eucolloids—Linear polymers of a degree of polymerization over 1000; that is, each molecule is made up of over 1000 units of a simple substance. They show pronounced swelling and their solutions are highly viscous. The solid eucolloids are very tough and hard.

Extrusion molding—A molding procedure for extended shapes of uniform cross-section, whereby a heat-softened substance is forced through an orifice of form coinciding with the cross-section of the article.

Flash mold—A mold designed to permit excess molding material to escape during final closing.

Fluidity—Reciprocal of the viscosity.

Gel—A somewhat rigid, generally transparent, two-phase liquid-solid system in which the solid is precipitated as aggregates in and around which the liquid is held.

Gelation—Formation of a gel.

Gums—Viscous vegetable secretions which harden but, unlike resins, are water-soluble. The name is often applied, particularly in the varnish industry, to natural resins such as copals.

Hemicolloids—Polymers of molecular weight up to 10,000, corresponding to an order of polymerization equal to 20 to 100 monomeric units. They dissolve without swelling and give solutions of low viscosity. Precipitation from solution yields powdery masses.

Injection molding—A molding procedure whereby a heat-softened plastic material is forced from a receptacle into a relatively cool cavity which gives the article of desired shape.

Laminated products—Sheets of material united by a binder. For example, sheets of paper or wood coated and/or impregnated with a resinous composition and subjected to pressure, generally with heat.

Lastic—A substance which at a certain temperature

exhibits the physical properties of rubber. Unlike a viscous liquid, stress causes deformation at this temperature but removal of stress results in substantial recovery of the original shape.

Linear molecule—A molecule of highly elongated form. Generally applied to straight-chain polymers.

Loss factor—The product of the power factor and the dielectric constant.

Macromolecule—A molecule of such size that it exhibits colloidal properties.

Mesocolloids—Polymers intermediate between hemicolloids and eucolloids; that is, of a degree of polymerization between about 100 and 1000.

Modulus of elasticity—The stress required to produce a unit distortion.

Monomer—The simplest repeating structural unit of a polymer. For addition polymers this represents the originally unpolymerized compound.

Natural resins—Solid substances from vegetable excretions exhibiting brittleness, vitreous luster, conchoidal fracture, water-insolubility and varying fusibility and solubility.

Novolak—A permanently fusible and soluble phenol-aldehyde resin. More specifically it is the reaction-product of 1 molecule of phenol with less than 1 molecule of formaldehyde, and an acid catalyst.

Phenoplast—A general term for phenol-aldehyde resins. Synonymous with popular term "phenolics."

Pitch—A dark-colored, fusible, more or less viscous to solid bituminous or resinous substance, insoluble in water but more or less soluble in carbon disulfide, benzol, etc. Composition and origin variable.

Plastic flow—Flow which is proportional to the pressure in excess of a certain minimum pressure (yield value) necessary to start the flow.

Plastics—All substances that can be molded. In general a plastic is a substance which behaves as a solid at stresses less than a certain amount known as the yield value and as a viscous liquid at stresses greater than this. The name is also applied to substances which originally but not ultimately fulfill this condition. For example, it is applied to thermoset compositions or resinoids in the final stages.

Plasticity—Susceptibility to and the retention of deformation. Capacity of taking and retaining the form of a mold. The property of solids by virtue of which they hold their shape permanently under the action of small shearing stresses but are readily deformed, worked or molded under larger stresses.

Polymerization—A chemical change resulting in the formation of a new compound whose molecular weight is a multiple of that of the original substance. The products of the reaction are called polymers. To distinguish from those resulting from condensation (q.v.), they are often designated addition polymers since the reaction is that of successive addition of a large number of relatively small molecules (monomers) to form the final polymer.

Positive mold—A mold designed to trap all the molding material to prevent its escape when it closes.

Power factor—In an insulating material, the ratio of total power loss (watts) in the material to the product of voltage and current in a capacitor in which that material is a dielectric.

Resin—A term generally referring to a physical condition at room temperature approximating the physical properties of natural resins (q.v.).

Resinoids—The class name applied to thermosetting resins. Temporary thermoplastics. The name is also often applied to the final cured resins.

Resite—A phenol-aldehyde resin in the C-stage (q.v.).

Resitol—A name often applied to a phenol-aldehyde resin in the B-stage (q.v.).

Resol—A name often applied to a potentially hardening phenol-aldehyde resin in the A-stage (q.v.).

Sol—A colloidal dispersion whose particles have sufficient Brownian motion to keep them in suspension.

Synthetic resin—A complex, substantially amorphous, organic semi-solid or solid material (usually a mixture of substances) built up by chemical reaction of comparatively simple compounds and, depending upon the temperature at which the examination is made, approximating the natural resins in various physical properties, namely: luster, fracture, comparative brittleness, insolubility in water, fusibility or plasticity when heated or exposed to heat and pressure, and, at a certain more or less narrow temperature range before fusion, showing a degree of rubber-like extensibility; but commonly deviating widely from natural resins in chemical constitution and behavior with reagents.

Synthetic rubber—Caoutchouc synthesized in the laboratory. The term is a misnomer and most probably represents an impossibility.

Tars—Dark-colored substances, liquid or semi-liquid at room temperature often possessing a characteristic "tarry" odor, usually insoluble in water but soluble in carbon disulfide, benzol, etc., and which on distillation, oxidation, etc., form a pitch. Composition variable.

Thermoplastic—The property of softening under heat. All molding materials are thermoplastic at the initial application of heat. One class (the so-called thermoplastics) remains soft permanently under heat; the other (thermosetting), after first softening, sets or cures more or less quickly to a more solid form.

Thermosetting—The property of undergoing a chemical change when heated whereby a hardened product is obtained. Property most pronounced in phenol- and urea-formaldehyde resins and less so with alkyds.

Thixotropy—The property by which certain compositions become solid when at rest but liquefy again on agitation.

Transfer molding—Another name for injection molding.

Treacle stage—A thermosetting resin in liquid form. Particularly applied to casting.

Viscosity—Internal friction or resistance to change of form of a liquid. The constant ratio of shearing stress to rate of shear.

Yield value—The lowest pressure at which a plastic will flow. Below this pressure the plastic behaves as an elastic solid; above this pressure as a viscous liquid.

PLASTICS AND RAW MATERIALS

USED IN MANUFACTURING PLASTIC COMPOSITIONS

ACIDS

American-British Chemical Supplies, Inc.
American Cyanamid & Chemical Corp.
Baker Castor Oil Co.
Baker Chemical Co., J. T.
Cliff Dow Chemical Co.
du Pont de Nemours & Co., Inc., E. I.
General Chemical Co.
Harshaw Chemical Co.
Hercules Powder Co.
Koppers Co.
Mallinckrodt Chemical Works
Monsanto Chemical Co.
National Aniline & Chemical Co., Inc.
National Oil & Supply Co.
Niacet Chemicals Corp.
Pacific Coast Borax Co.
Penn Salt Mfg. Co.
Reilly Tar & Chemical Corp.

ALDEHYDE AMMONIA

du Pont de Nemours & Co., Inc., E. I.
Niacet Chemicals Corp.

CAMPHOR

du Pont de Nemours & Co., Inc., E. I.
Mallinckrodt Chemical Works

CASEIN

American-British Chemical Supplies, Inc.
American Cyanamid & Chemical Corp.
American Plastics Corp.
Hercules Powder Co.
Innis, Speiden & Co., Inc.
Merchants Chemical Co., Inc.
Merck & Co., Inc.

CASEIN

(Rods-Sheets-Tubes)

American Plastics Corp.
Morrell Corp., George
Nixon Nitration Works

CELLULOSE ACETATE

(Flake)

American-British Chemical Supplies, Inc.
American Cellulose Co.
Hercules Powder Co.
Meyer & Co., W. & G.
Tennessee Eastman Corp.

CELLULOSE ACETATE

(Rods-Sheets-Tubes)

American Cellulose Co.
American Prod. Mfg. Co. (sheets only)
Celluloid Corp.
Cinelin Company
du Pont de Nemours & Co., Inc., E. I.
Eastman Kodak Co.
Insel Co.
Masury & Son, John W.
Monsanto Chem. Co., Plastics Div.
Nixon Nitration Works
U. S. Industrial Chemicals, Inc.

CELLULOSE NITRATE

(Rods-Sheets-Tubes)

American Cellulose Co.
Auburn Button Works, Inc.
Celluloid Corp.
Cinelin Company
du Pont de Nemours & Co., Inc., E. I.
Eastman Kodak Co.
Insel Co.
Mallinckrodt Chemical Works
Monsanto Chem. Co., Plastics Div.
Nixon Nitration Works
Sylvania Industrial Corp.

CELLULOSE

(Nitrocotton)

American Cellulose Co.
American Cyanamid & Chemical Corp.
General Chemical Co.
Hercules Powder Co.
Monsanto Chemical Co., Plastics Div.

CHLORINATED RUBBER

Hercules Powder Co.

COLORS

(See Dyes; Pigments)

DENTURE MATERIALS

Bakelite Dental Prods., Inc.
Celluloid Corp.
du Pont de Nemours & Co. Inc., E. I.
Monsanto Chem. Co., Plastics Div.
Nixon Nitration Works
Röhm & Haas Co.

DYES

American Aniline Products, Inc.
Calco Chemical Co., Inc.
du Pont de Nemours & Co., Inc., E. I.
Monsanto Chemical Co.
National Aniline & Chemical Co., Inc.

ETHYLCELLULOSE

American Cellulose Co.
American Products Mfg. Co.
Dow Chemical Co.
Hercules Powder Co.

FILLERS, ALPHA CELLULOSE

Brown Co.

FILLERS, COTTON FLOCK

Claremont Waste Mfg. Co.
Peckham Mfg. Co., The
Rayon Processing Co., The

FILLERS, DIATOMACEOUS

Dicalite Co.
Johns-Manville
Wishnick-Tumpeer, Inc.

FILLERS, MINERAL

American-British Chemical Supplies, Inc.
Dicalite Co.
International Pulp Co.
Johns-Manville
Ruberoid Co.
Vermont Asbestos Co.
Williams & Co., C. K.
Wishnick-Tumpeer, Inc.

FILLERS, SILICA

Dicalite Co.
International Pulp Co.
Johns-Manville
Loomis Talc Corp., W. H.
Monsanto Chemical Co.
Williams & Co., C. K.

FILLERS, WOODFLOUR

American Woodflour Co., Inc.
Becker, Moore & Co.
Burnet Co., The
Composition Materials Co., Inc.
Connor Lumber and Land Co.
Doe & Ingalls, Inc.
du Pont de Nemours & Co., Inc., E. I.
Innis, Speiden & Co., Inc.
Lignum Chemical Works, The
Soberski, B. L.
State Chemical Co.
Wishnick-Tumpeer, Inc.

FORMALDEHYDE

American Cyanamid & Chemical Corp.
du Pont de Nemours & Co., Inc., E. I.
General Chemical Co.
Harshaw Chemical Co.
Hercules Powder Co.
Heyden Chemical Corp.
Kay-Fries Chemicals, Inc.
Mallinckrodt Chemical Works
Merck & Co., Inc.
National Oil & Supply Co.

HEXAMETHYLENETETRAMINE

American-British Chemical Supplies, Inc.
Baker Chemical Co., J. T.
du Pont de Nemours & Co., Inc., E. I.
Heyden Chemical Corp.
Mallinckrodt Chemical Works
Merck & Co., Inc.
Wishnick-Tumpeer, Inc.

LACQUERS, CELLULOSE

American Products Mfg. Co.
du Pont de Nemours & Co., Inc., E. I.
Eastman Kodak Co.
Egyptian Lacquer Mfg. Co.
Maas & Waldstein Co.
Masury & Son, John W.
Monsanto Chem. Co.
Pyroxylin Products Corp.
Resinous Products & Chemical Co.
Roxalin Flexible Lacquer Co., Inc.
Stanley Chemical Co.

LACQUERS, RESIN

American Products Mfg. Co.
Bakelite Corp.
Catalin Corp.
du Pont de Nemours & Co., Inc., E. I.
Durite Plastics, Inc.
Egyptian Lacquer Mfg. Co.
Masury & Son, John W.
Monsanto Chemical Co.
Pyroxylin Products, Inc.
Resinous Products & Chemical Co.

METHYL METHACRYLATE

(Rods-Sheets-Tubes)

du Pont de Nemours & Co., Inc., E. I.
Resinous Products & Chemical Co.
Röhm & Haas Co.

(Solutions)

Resinous Products & Chemical Co.

Addresses of companies listed appear on pages 449–452, this section

MICA

American-British Chemical Supplies, Inc.
American Cyanamid & Chemical Corp.
Burnet Co., The
Harshaw Chemical Co.
Maryland Chemical Co.
Mica Insulator Co.
Munsell & Co., Eugene
Westinghouse Elec. & Mfg. Co.
Wishnick-Tumpeer, Inc.

MOLDING & LAMINATING BOARDS AND BLANKS

Bakelite Corp.
Bakelite-Rogers Co., Inc.
Dispersion Products Co.
Mica Insulator Co.
Taylor-Atkins Paper Mills
Westinghouse Elec. & Mfg. Co.

MOLDING COMPOUNDS, CELLULOSE ACETATE

Bakelite Corp.
Celluloid Corp.
du Pont de Nemours & Co., Inc., E. I.
Masury & Son, John W.
Meyer & Co., W. & G.
Monsanto Chem. Co., Plastics Div.
Nixon Nitration Works
Tennessee Eastman Corp.

MOLDING COMPOUNDS, CELLULOSE ACETATE BUTYRATE

Masury & Son, John W.
Nixon Nitration Works
Tennessee Eastman Corp.
Meyer & Co., W. & G.

MOLDING COMPOUNDS, ETHYLCELLULOSE

Dow Chemical Co.
Masury & Son, John W.

MOLDING COMPOUNDS, METHYL METHACRYLATE

du Pont de Nemours & Co. Inc., E. I.
Röhm & Haas Co.

MOLDING COMPOUNDS, PHENOL-FORMALDEHYDE

Bakelite Corp.
Catalin Corp.
Durez Plastics & Chemicals, Inc.
Makalot Corp.
Monsanto Chemical Co., Plastics Div.
Reilly Tar & Chemical Corp.
Resinox Corp.
Superior Plastics Co.

MOLDING COMPOUNDS, PHENOL-FURFURAL

Durite Plastics, Inc.

MOLDING COMPOUNDS, STYRENE

Bakelite Corp.
Carbide & Carbon Chemicals Corp.
Dow Chemical Co.
Monsanto Chemical Co., Plastics Div.

MOLDING COMPOUNDS, UREA-FORMALDEHYDE

Bakelite Corp.
Beetle Prods. Div. of American Cyanamid Co.
Plaskon Co., Inc.

MOLDING COMPOUNDS, VINYL RESINS

Carbide & Carbon Chemicals Corp.
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Beck Machine Co., Chas.
Birdsboro Steel Foundry & Machine Co.
Bliss Co., E. W.
Burroughs Engineering Co.
Carver, Fred S.
Cavagnaro, John J.
Chambersburg Engineering Co.
Dunning & Boschert Press Co.
Elmes Engineering Works, Chas. F.
Farrel-Birmingham Co.
French Oil Mill Machinery Co.
Hydraulic Press Mfg. Co.
Krehbiel Co., Inc., J. J.
Lake Erie Engineering Corp.
Loomis Co., Evarts G.
Peerless Roll Leaf Co., Inc.
Robertson Co., Inc., John
Standard Machinery Co.
Standard Tool Co.
Stokes Machine Co., F. J.
Trand & Sons, Alex
Watson-Stillman Co.
Wood Co., R. D.

PRESSES, EXTRUDING

Albert & Son, L.
Aurelio Tanzi Eng. Co.
Baldwin-Southwark Corp.
Birdsboro Steel Foundry & Machine Co.
Burroughs Engineering Corp.
Carver, Fred S.
Cavagnaro, John J.
Dunning & Boschert Press Co.
Elmes Engineering Corp., Chas. F.
Farrel-Birmingham Co.
Farquhar Co., Ltd., A. B.
French Oil Mill Machinery Co.
Hydraulic Press Mfg. Co.
Index Machinery Corp.
Krehbiel Co., Inc., J. J.
Loomis Co., Evarts G.
Royle & Sons, John
Watson-Stillman Co.

PRESSES, HOBBING

Baldwin-Southwark Corp.
Birdsboro Steel Foundry & Machine Co.
Bliss Co., E. W.
Burroughs Engineering Co.
Elmes Engineering Works, Chas. F.
French Oil Mill Machinery Co.
Hydraulic Press Mfg. Co.
Lake Erie Engineering Corp.
Loomis Co., Evarts G.
Midland Die & Engraving Co.
Newark Die Co.
Robertson Co., Inc., John
Watson-Stillman Co.
Williams-White & Co.
Wood Co., R. D.

PRESSES, HYDRAULIC

Albert & Son, L.
Baldwin-Southwark Corp.
Birdsboro Steel Foundry & Machine Co.
Bliss Co., E. W.
Burroughs Engineering Co.
Carver, Fred S.
Dunning & Boschert Press Co.
Elmes Engineering Works, Chas. F.
Emerman & Co., Louis E.
Farrel-Birmingham Co., Inc.
French Oil Mill Machinery Co.
Hannifin Mfg. Co.
Hydraulic Press Mfg. Co.
Index Machinery Corp.
Kux-Lohner Machine Co.
Lake Erie Engineering Corp.
Logemann Bros. Co.
Loomis Co., Evarts G.
National Erie Co.
Spadone Machine Co., Inc.
Standard Machinery Co., The
Stokes Machine Co., F. J.
Watson-Stillman Co.
Williams-White & Co.
Wood Co., R. D.

PRESSES, INJECTION MOLDING

Burroughs Engineering Co.
De Mattia Machine & Tool Co.
Grotelite Co.
Hydraulic Press Mfg. Co.
Index Machinery Corp.
Krehbiel Co., Inc., J. J.
Kux-Lohner Machine Co.
Lester Engineering Co.
Loomis Co., Evarts G.
Modern Die & Mold Co.
Reed-Prentice Corp.
Standard Tool Co.
Watson-Stillman Co.

PRESSES, INLAYING

Ams Machine Co., Max
Birdsboro Steel Foundry & Machine Co.
Bliss Co., E. W.
Cameron Can Machinery Co.
Carver, Fred S.
Grimes & Harris, Inc.
Hydraulic Press Mfg. Co.
Index Machinery Corp.
Niagara Machine & Tool Works
Peck-Stow & Wilcox Co.
Plastic Inlays, Inc.
Standard Tool Co.
Stokes Machine Co., F. J.

PRESSES, LABORATORY

Adamson Machine Co.
Albert & Son, L.
Aurelio Tanzi Eng. Co.
Baldwin-Southwark Corp.
Birdsboro Steel Foundry & Machine Co.
Burroughs Engineering Co.
Carver, Fred S.
Cavagnaro, John J.
Colton Co., Arthur
Eimer & Amend
Elmes Engineering Works, Chas. F.
Farquhar Co. Ltd., A. B.
Farrel-Birmingham Co.
French Oil Mill Machinery Co.
Hannifin Mfg. Co.
Hydraulic Press Mfg. Co.
Krehbiel Co., Inc., J. J.
Loomis Co., Evarts G.
Standard Machinery Co.
Stokes Machine Co., F. J.
Terkelsen Machine Co.
Watson-Stillman Co.
Williams-White & Co.
Wood Co., R. D.
White Dental Mfg. Co., S. S., Ind. Div.

PRESSES, PREFORMING

Colton Company, Arthur
Hydraulic Press Mfg. Co.
Kux-Lohner Machine Co.
Stokes Machine Co., F. J.

PRESSES, STAMPING

Ackerman-Gould Corp.
Kingsley Gold Stamping Machine Co.
Peerless Roll Leaf Co., Inc.

PRESSES, TOGGLE

Albert & Son, L.
Ams Machine Co., Max
Bliss Co., E. W.
Dunning & Boschert Press Co.
Engineering Laboratories, Inc.
French Oil Mill Machinery Co.
Grimes & Harris, Inc.
Index Machinery Corp.
Krehbiel Co., Inc., J. J.
Kux-Lohner Machine Co.
Logemann Bros. Co.
Niagara Machine & Tool Works
Standard Machinery Co.
Standard Tool Co.
Stokes Machine Co., F. J.
Terkelsen Machine Co.
Toledo Machine & Tool Co.

PUMPS, HYDRAULIC

Albert & Son, L.
Aldrich Pump Co.
American Engineering Co.
American Steam Pump Co.
American Well Works
Baldwin-Southwark Corp.
Barnes Corp., John S.
Birdsboro Steel Foundry & Machine Co.
Browne & Sharpe Mfg. Co
Burroughs Engineering Co.
Carbondale Machine Co.
Chambersburg Engineering Co.
De Laval Steam Turbine Co.
Dunning & Boschert Press Co.
Elmes Engineering Works, Chas. F.
Erie Pump & Engine Works
Farquhar Co., Ltd., A. B.
French Oil Mill Machinery Co.
Hydraulic Engineering Works
Hydraulic Press Mfg. Co.
Ingersoll Rand Co.
Logemann Bros. Co.
Loomis Co., Evarts G.
Robertson Co., Inc., John
Union Steam Pump Co.
Vickers, Inc.
Watson-Stillman Co.
Worthington Pump & Machinery Corp.

PUMPS, VACUUM

Albert & Son, L.
Aldrich Pump Co.
Beach-Russ Co.
Cincinnati Lathe & Tool Co.
Ingersoll Rand Co.
Kinney Mfg. Co.
Lammert & Mann Co.
Loomis Co., Evarts G.
Nash Engineering Co.
National Scientific Corp.
Pennsylvania Pump & Compressor Co.
Stokes Machine Co., F. J.
Union Steam Pump Co.
Worthington Pump & Machinery Corp.

PYROMETERS

Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cambridge Instrument Co., Inc.
Engelhard, Inc., Chas.
Foxboro Co.
Hoskins Mfg. Co.
Illinois Testing Laboratories, Inc.
Index Machinery Corp.
Leeds & Northrup Co.
Loomis Co., Evarts G.
Minneapolis Honeywell Regulator Co.
Pyrometer Instrument Co.
Republic Flow Meters Co.
Russell Electric Co.
Tagliabue Mfg. Co., C. J.
Taylor Instrument Co.
Thwing-Albert Instrument Co.
Wilson-Maeulen Pyrometer Co.

STEEL FOR HOBS

Achorn Steel Co.
Carpenter Steel Co.
Jessop & Sons, Inc., Wm.
McDonald & Co., P. F.
Republic Steel Corp.

STEEL FOR MOLDS

Achorn Steel Co.
American Rolling Mills
Carpenter Steel Co.
Crucible Steel Co. of America
Hawkridge Bros. Co.
Jessop & Sons, Inc., Wm.
Latrobe Elec. Steel Co.
Ludlum Steel Co.
McDonald & Co., P. F.
Republic Steel Corp.
Vanadium Alloy Steel Co
Ziv Steel and Wire Co.

TESTING APPARATUS

Baldwin-Southwark Corp.
Brown Instrument Co.
Olsen Testing Machine Co., Tinius
Scott Co., Henry L.
Shallcross Mfg. Co.
Thwing-Albert Instrument Co.

TIMING DEVICES

Cramer Co., Inc., R. W.
Industrial Instrument Co.
Leeds & Northrup Co.
Partlow Corp.

MOLDERS, FABRICATORS, DESIGNERS

AND OTHER INCIDENTAL SERVICES

COLD MOLDERS

American Insulator Corp.
Cutler-Hammer, Inc.
Garfield Mfg. Co.
General Electric Co., Plastics Dept.
Haveg Corp.
International Molded Plastics, Inc.
Keasbey & Mattison
Plastic Molding Corp.

CONSULTING AND TESTING

Alexander, Jerome, 50 E. 41St., N. Y. C.
Baldwin Laboratories, Inc., Main St., Saeger Town, Pa.
Electrical Testing Laboratories, 79th St. & East End Ave., New York, N. Y.
Ellis Laboratories, Inc., 98 Greenwood Ave., Montclair, N. J.
Esselen, G. T., 73 Newbury, Boston, Mass.
Grosvenor, Wm. M., 50 E. 41 St., N. Y. C.
Industrial Research and Engineering Co., 7325 Penn Ave., Pittsburgh, Pa.
Little, Inc., A. D., 30 Charles River Road, Cambridge, Mass.
New York Testing Laboratories, 80 Washington St., New York, N. Y.
Norton, Arthur J., Box 1745, Portland, Me.
Orthmann Laboratories Inc., The, Milwaukee, Wis.
Pellerano, S., 1918 71 St., Brooklyn, N. Y.
Pittsburgh Testing Laboratory, Stevenson St. at Locust, Pittsburgh, Pa.
Pollak, Dr. Fredr., 114 E. 32 St., N. Y. C.
Simonds, J. Earl, 5 de Forest Ave., Summit N. J.
Snell, F. D., 305 Washington St., Brooklyn, N. Y.
Stringfield, R. B., 229 S. Normandy Ave., Los Angeles, Cal.
United States Testing Co., Inc., 1415 Park Ave., Hoboken, N. J.
Wilmington Testing and Research Laboratories, 1002 West St., Wilmington, Del.

CUSTOM MOLDERS

Accurate Molding Corp.
Ackerman Rubber & Plastic Molding Co.
Advance Molding Corp.
Alden Products Co.
Allied Plastics Corp.
American Hard Rubber Co.
American Insulator Corp.
American Molding Co.
Anchor Cap & Closure Corp.
Armstrong Cork Products Co., Closure Division
Associated Attleboro Mfrs., Inc.
Atlantic Plastic & Metal Parts Co.
Auburn Button Works, Inc.
Automatic Molded Prods. Co.
Baldwin Laboratories, Inc.
Ballard Plastics Corp.
Barber-Coleman Co.
Bay Mfg. Co., The
Bay State Molding Co.
Boonton Molding Co.
Breeze Corp.
Bridgeport Molded Products, Inc.
Brill-Monfort Co., Inc.
Butterfield, Inc., T. F.
California Plastic Molding Co.
Chicago Die Mold Mfg. Co.
Chicago Molded Products Corp.
Cincinnati Molding Co.
Climax Mfg. & Molding Corp.
Colt's Patent Fire Arms Mfg. Co.
Compo-site, Inc.
Consolidated Molded Products Corp.
Cutler-Hammer, Inc.
Davies Molding Co., Harry
Dayton Insulating Molding Co.
Diemolding Corp.
Eagle Plastic Corp.
Eclipse Moulded Products Co.
Economy Fuse & Mfg. Co.
Erie Resistor Corp.
Eureka Button Co.
Firestone Tire & Rubber Co., Plastics Div.
Garfield Mfg. Co.
General Electric Co., Plastics Dept.
General Industries Co.
General Insulate Co., Inc.
General Molding Co.
General Products Corp.

Addresses of companies listed appear on pages 449–452, this section

CUSTOM MOLDERS *(Cont.)*

Gibbs Mfg.
Globe Tool & Molded Prod. Co.
Gorham Company, Plastics Division
Grigoleit Co.
Gulliksen Mfg. Co., W. M.
Hahn Plastic & Die Cast Corp.
Hyde, A. L.
Imperial Molded Products Corp.
Industrial Molded Prods. Co.
Inland Mfg. Div., General Motors Corp.
Insulation Mfg. Co., Inc.
Insulation Prods. Co.
International Molded Plastics, Inc.
Jamison, H.
Keasbey & Mattison
Keeler Brass Co.
Kellogg Switchboard & Supply Co.
Keystone Specialty Co.
Kuhn & Jacob Moulding & Tool Co.
Kurz-Kasch, Inc.
Lanfare Molded Products
Lapin-Kurley Kew, Inc.
Leviton Mfg. Co.
Mack Molding Co., Inc.
Marmont Plastics, Inc.
Martindell Molding Co.
Meissner Mfg. Co.
Mico, Inc.
Midwest Molding & Mfg. Co.
Mills Corp., Elmer E.
Modern Plastics Corp.
Molded Insulation Co.
Molded Plastics, Inc.
Molded Products Co.
Molding Corp. of America
National Lock Co.
National Plastics, Inc.
Niagara Insul-Bake Specialty Co., Inc.
Northern Industrial Chemical Co.
Norton Laboratories, Inc.
Oris Mfg. Co.
O'Shei, B. F.
Owens-Illinois Glass Co., Closure Div.
Paulis, Inc., H.
Peerless Molded Plastics, Inc.
Plano Molding Co.
Plastic Jewelry, Inc.
Plastic Molded Arts, Inc.
Plastic Molding Corp.
Plastic Moldings Corp.
Plastic Products, Inc.
Plastic-Ware, Inc.
Plastics, Inc.
Quintard & McIlhiney
Rathbun Molding Corp.
Recto Molded Products, Inc.
Reinhold Co., F. E.
Remler Co., Ltd.
Reynolds Spring Co., Molded Plastics Div.
R. I. Moulding Works
Richardson Company
Royal Molding Co.
Salz Bros., Inc.
Shaw Insulator Co.
Sheller Mfg. Co.
Siemon Company
Specialty Insulation Co.
Standard Cap & Molding Co.
Standard Plastics Co.
Sterling Plastics Co.
Stokes Rubber Co., Jos.
Synthetic Moulded Products, Inc.
Tech-Art Plastics Co.
Terkelsen Machine Co.
Union Insulating Co.
United Comb & Novelty Co.
U. S. Plastic Corp.
Universal Plastics Corp.
Valley Molding Co.
Van Norman Molding Co.
Victor Metal Prods. Corp.
Victory Molding Co.
Voges Mfg. Co.
Ward Plastic & Rubber Co.
Waterbury Button Co.
Watertown Mfg. Co.
Wheeling Stamping Co.
White Dental Mfg. Co., S. S., Ind. Div.
Windman Bros.
Ziwel Plastics Corp.

DECORATION, APPLIED

(Printing, Stamping, Engraving, Inlays, Etc.)

Color-Kraft, Inc.
Gemloid Corp.
Griffin, Campbell, Hayes, Walsh, Inc.
Kingsley Gold Stamping Machine Co.
Palm Fechteler & Co.
Peerless Roll Leaf Co., Inc.
Plastic Inlays, Inc.
Plastiograph Co.
Probar Corp.
Quick Point Pencil Co.
Rogan Bros.

DESIGNERS, INDUSTRIAL

Ackerman, Jay, Warren, Conn.
Adams, Wilbur Henry, 2341 Carnegie Ave., Cleveland, Ohio.
Adler, S. E.; Modern Industrial Designers, 4544 N. Hazel Ave., Chicago, Ill.
Alcott, Thoner & Marsh, 271 East St., Islington, Mass.—833 Park Sq. Bldg., Boston, Mass.
Arens, Egmont, 480 Lexington Ave., N.Y.C.
Aronson, Joseph, 215 East 58 St., N. Y. C.
Bach, Alphonse, 724 Fifth Ave., N. Y. C.
Bach, Oscar, 305 East 46 St., N. Y. C.
Barnes & Reinecke, 664 No. Michigan Ave., Chicago, Ill.
Bel Geddes, Norman, 50 Rockefeller Plaza, N. Y. C.
Bernhard, Lucian, 120 East 86 St., N. Y. C.
Bernstein, Arthur, 215 W. 91 St., N. Y. C.
Blow, George; De Vaulchier, Blow and Wilmet, 51 East 42 St., N. Y. C.
Brown, E. Norris, 15 Bradford Pl., Brockton, Mass.
Budlong, Inc., Robert D., 333 N. Michigan Ave., Chicago, Ill.
Bureau, Achille G., 374 Burns St., Forest Hills, N. Y.
Casoyd, Sydney, 40 East 48 St., N. Y. C.
Castaing, C. K., Stony Brook, L. I.
Cheron, Pierre, 65 Locust, Stratford, Conn.
Conant, Roger, 123 East 53 St., N. Y. C.
Covington-Burwick, 206 Oak Knoll, Mankato, Minn.
D'Addario, Thomas, 11 W. 42 St., N. Y. C.
Daly, Grover, J., 545 Vernon, Glencoe, Ill.
Designers for Industry, Inc., Merchandise Mart, Chi., Ill.; Terminal Tower, Cleveland, O.; 630 5th Ave., N. Y. C.
Deskey, Donald, 630 Fifth Ave., N. Y. C.
De Vaulchier, Simon; De Vaulchier, Blow and Wilmet, 51 East 42 St., N. Y. C.
De Vries, Herman, 49 W. 45 St., N. Y. C.
Dreyfuss, Henry, 501 Madison, N. Y. C.
Dryden, Helen, 25 Fifth Ave., N. Y. C.
Dulany, Helen Hughes, 936 Lake Shore Drive, Chicago, Ill.
Ehlert, Harold H., 730 Whitmore Rd., Detroit, Mich.
Erwin, Hobe G., 15 East 57 St., N. Y. C.
Farr, Fred, 311 Prospect Ave., Mamaroneck, N. Y.
Federico, Jos. B., Portage Rd., Niagara Falls, N. Y.
French, Carroll, 116 Waverly Pl., N. Y. C.
Gaba, Lester, 347 Fifth Ave., N. Y. C.
Gates, John M., 1 East 53 St., N. Y. C.
Gerth, Ruth K., 104 East 40 St., N. Y. C.
Gerth, William, 1625 Second Ave., N. Y. C.
Guild, Lurelle, 522 Fifth Ave., N. Y. C.
Hall, Frances C., 24 Fifth Ave., N. Y. C.
Hamil, Virginia, 6 East 45 St., N. Y. C.
Heller, Inc., Robert, 50 Rockefeller Plaza, N. Y. C.
Hess, C. R., Theodore, Prairie View, Ill.
Hodges, Guy W., 10 East 40 St., N. Y. C.
Hoopes, Cunningham & McKinney, 12 S. 12 St., Phila., Pa.
Hornung, Clarence P., 23 W. 47, N. Y. C.
Jackson, Edwin, 175 East 60 St., N. Y. C.
Jensen, Gustav, 16 E. 48 St., N. Y. C.
Jiranek, Leo, 30 Rockefeller Plaza, N. Y. C.
Johnson & Zaiser, 27 West 57 St., N. Y. C.
Keirstead, E. Warner, 74 Stewart Ave., Mansfield, Ohio.
Ketcham, Howard, 30 Rockefeller Plaza, N. Y. C.
Kiesler, Frederic, 56 Seventh Ave., N. Y. C.
Kogan, Belle, 185 Madison Ave., N. Y. C.
Korda Graphics, 41 Union Sq., N. Y. C.
Lescaze, William, 211 E. 48 St., N. Y. C.
Linder, Laura Lee, Pittsfield, Mass.
Little, John, 101 Park Ave., N. Y. C.
Loewy, Raymond, 580 Fifth Ave., N. Y. C.
Lux, Eugene, 44 W. 56 St., N. Y. C.
MacAlister, Paul, 30 Rockefeller Plaza, N. Y. C.
Mandle, Earl, 515 30 St., N. Bergen, N. J.
Martial Associates, Jacques, 41 Union Sq., N. Y. C.
Miller Co., H. Wood, 1545 Rockingham St., Davenport, Ia.
Miller, Frances T., 24 W. 55 St., N. Y. C.
Muffitt, J. Albert, 139 72 St., Niagara Falls N. Y.
Muller, Theodore Carl, 9 Rockefeller Plaza, N. Y. C.
Muller-Munk, Peter, Carnegie Tech., Pittsburgh, Pa.
Nash, Ben, 30 Rockefeller Plaza, N. Y. C.
Olsen Designers, 160 W. Walton, Chi., Ill.
O'Neil, William, 50 Rockefeller Plaza, N. Y. C.
Orcutt, Philip Dana, 93 W. Cedar St., Boston, Mass.
Parzinger, Tommi, 320 E. 57 St., N. Y. C.
Petrucelli, Antonio, 30 E. 20 St., N. Y. C.
Post Studios, Harold, Hartford, Conn.
Preis, Marion, 177 E. 87 St., N. Y. C.
Ressinger, Paul, Chicago, Ill.
Rideout, Jack, 520 Caxton Bldg., Cleveland, Ohio
Rohde, Gilbert, 22 E. 60 St., N. Y. C.
Root, John, 3728 Lowell Ave., Chi., Ill.
Sakier, George, 40 W. 40 St., N. Y. C.
Sanders, Morris B., 219 E. 49 St., N. Y. C.
Saymon, Inc., Clarice, 9 Rockefeller Plaza, N. Y. C.
Scheele, Edwin H., 419 4th Ave., N. Y. C.
Simonson, Lee, 411 East 50 St., N. Y. C.
Slobodkin, Simon, 39 W. 23 St., N. Y. C.
Spilman, Raymond, 7451 Woodward Ave., Detroit, Mich.
Streng, Jan, Mason, N. H.
Sundberg & Ferar, 207 Stephenson Bldg., Detroit, Mich.
Superior Engineering, 189 W. Madison St., Chicago, Ill.
Swibold, Duane, 1406 Penobscot Bldg., Detroit, Mich.
Switzer, George, 45 Charles St., N. Y. C.
Szabo, Bela, 607 W. 43 St., N. Y. C.
Teague, Walter Dorwin, 210 Madison Ave., N. Y. C.
Teegan, Otto, 5 East 57 St., N. Y. C.
Thelander, Clement J., 646 No. Michigan Ave., Chicago, Ill.
Trace & Warner, 155 N. Clark St., Chicago, Ill.
Tupper, Earl S., 147 7 St., Leominster, Mass.
Van Doren, Harold, 1217 Madison Ave., Toledo, Ohio
Van Veen, Stuyvesant, 24 W 96, N. Y. C.
Vassos, John, Comstock Hill, Norwalk, Conn.
Versen, Kurt, 373 Fourth Ave., N. Y. C.
Voges, George Arthur, 389 Central St., Springfield, Mass.
Von Nessen, Walter, 211 E. 49 St., N. Y. C.
Waltman & Associates, C. E., Chicago, Ill.
Warner, Sidney G., The Woman's College of The University of North Carolina, Greensboro, N. C.
Weill, Inc., Paul, 40 E. 49th St., N. Y. C.
Wieselthier, Vally, 301 East 38 St., N. Y. C.
Wilson, Scott, 1 East 53 St., N. Y. C.
Wright, Russel, 130 East 40 St., N. Y. C.

FABRICATORS, CASEIN

A. J. & K Co., Inc.
American Phenolic Corp.
Baff Mfg. Co.
Caldwell Products, Inc.
Commonwealth Plastics Co.
Dayton Insulating Molding Co.
Keolyn Plastics Co.
La Mode Plastic Co., Inc.
Morrell Corp., George
Timely Novelty Co.
United Comb & Novelty Co.
U. S. Plastic Corp.
Voges Mfg. Co., Inc.

FABRICATORS, CAST RESIN

Ace Plastic Novelty Corp.
A. J. & K. Co., Inc.
Alesite Corp.
American Phenolic Corp.
Baff Mfg. Co.
Caldwell Products, Inc.
Chicago Button & Buckle Co.
Colonial Kolonite Co.
Commonwealth Plastics Co.
Ditglo Mfg. Co., Inc.
Expert Celluloid Co., Inc.
Gibbs Mfg.
H. G. Specialty Co.
Hurst, Inc.
Ivorycraft Co., Inc.
Keolyn Plastics Co.
King Mfg. Co., J. M.
Krest Mfg. Co.
La Mode Plastic Co., Inc.
Lapin-Kurley Kew, Inc.
Monsanto Chemical Co., Plastics Div.
National Lock Co.
New England Novelty Co.
New England Plastic Spec. Co.
Ortho Plastic Novelties, Inc.
Plastic Novelties, Inc.
Plastic Specialties, Inc.
Plastic Turning Co.
Plastik, Inc.
Rex Products Corp.
Rogers Mfg. Co., The
Royson Plasticraft Co.
Select Novelty Co., Inc.
Turner, Douglas
Turner Plastic Prods. Co.
Uncas Mfg. Co.
United Comb & Novelty Co.
U. S. Plastic Corp.
Victory Molding Co.
Voges Mfg. Co., Inc., The

FABRICATORS, LAMINATES

(Punched and Fabricated Parts, Gear Blanks, Etc.)

Alden Products Co.
Alesite Corp.
Continental-Diamond Fibre Co.
Formica Insulation Co.
General Electric Co., Plastics Div.
National Vulcanized Fibre Co.
Spaulding Fibre Co., Inc.
Synthane Corp.
Taylor Fibre Co.
Westinghouse Elec. & Mfg. Co., Micarta Div.

FABRICATORS, PYROXYLIN AND CELLULOSE ACETATE

Auburn Button Works, Inc.
Bachmann Bros., Inc.
Baff Mfg. Co.
Berkander, Geo. F.
Camillus Cutlery Co.
Cotan Corp.
Cruver Mfg. Co.
Elkloid Co., The
Emeloid Co., The
Felsenthal & Sons, G.
Foster Grant Co., Inc.
Gemloid Corp.
Johnson Fare Box Co.
Keolyn Plastics Co.
Kingman Co., E. B.
Kippy Kit Co.
Markilo Co.
Nichols Products Co., Inc.
Parisian Novelty Corp.
Quick Point Pencil Co.
Rex Products Corp.
Salz Bros., Inc.
Tilton-Cook Co.
United Comb & Novelty Co.
U. S. Plastic Corp.
Van Arnam Mfg. Co.
Williams & Marcus Co.

FABRICATORS, PYROXYLIN COATING

Athol Manufacturing Co.
Boston Woven Hose and Rubber Co.
Bowen Mills, Inc.
Carpenter & Co., L. E.
Chase & Co., L. C.
Columbus Coated Fabrics Co.
Cotan Corp.
Cotex Corp.
Davis, Kraus & Miller
Federal Leather Co.
Holliston Mills, The
Interlaken Mills
Keratol Co., The
Landers Corp.
Masland Duraleather Co.
Pantasote Leather Co.
Permatex Fabrics Co., The
St. Clair Rubber Co.
Standard Textile Prods. Co.
Textileather Corp.
Western Shade Cloth Co.
Weymouth Art Leather Co.
Zapon Co., The

FABRICATORS, RUBBER MOLD CASTING

Art Plastic Co.
Castaing, C. K.

FABRICATORS, VINYL

American Phenolic Corp.
Carbide and Carbon Chemicals Corp., Vinylite Div.
Gemloid Corp.
Nichols Products Co., Inc.
Parisian Novelty Corp.
Resistoflex Corp.
U. S. Plastic Corp.

INJECTION MOLDERS, CUSTOM

Advance Molding Corp.
Allied Plastics Corp.
American Insulator Corp.
American Molding Co.
American Phenolic Corp.
Amos-Thompson Corp., Edinburg, Ind.
Atlantic Plastic & Metal Parts Co.
Bachmann Bros., Inc.
Baldwin Laboratories, Inc.
Ballard Plastics Corp.
Bay Mfg. Co.
Belmont Molded Plastics, Inc.
Boonton Molding Co.
Bridgeport Molded Products, Inc.
Butterfield, Inc., T. F.
Caldwell Products, Inc.
Cardinal Corp.
Chicago Molded Products Corp.
Claremould Plastics Corp.
Colt's Patent Fire Arms Mfg. Co.
Columbia Protektosite Co., Inc.
Columbus Plastic Products, Inc.
Commonwealth Plastics Co.
Consolidated Molded Products Corp.
Cruver Mfg. Co.
Detroit Macoid Co.
Emeloid Co.
Erie Plastics Co.
Erie Resistor Corp.
Firestone Tire & Rubber Co., Plastics Div.
Foster-Grant Co., Inc.
Gemloid Corp.
General Electric Co., Plastics Dept.
General Industries Co.
Gits Molding Corp.
Hahn Plastic Die Cast Corp.
Hyde, A. L.
Inland Mfg. Div., General Motors Corp.
Jamison, H.
Keeler Brass Co.
Keolyn Plastics Co.
Kingman Company, E. B.
Mack Molding Co.
Mason & Co., Thomas
Merrigan Plastic Co.
Metal Specialty Co.
Mills Corp., Elmer E.
Modern Plastic Co.
Modern Plastics Corp.
Molded Insulation Co.
Molded Plastics, Inc.
National Lock Co.
National Plastics, Inc.
Northern Industrial Chemical Co.
Norton Laboratories, Inc.
Ohio Plastics Co.
Paulis, Inc., H.
Peerless Molded Plastics, Inc.
Plastic Jewelry, Inc.
Plastic Molded Arts, Inc.
Plastic Molding Corp.
Plastic Products, Inc.
Plastics, Inc.
Recto Molded Products, Inc.
Remler Co., Ltd.
Reynolds Spring Co., Molded Plastic Div.
R. I. Moulding Works
Richardson Co.
St. Louis Plastic Moulding Co.
Salz Bros, Inc.
Shaw Insulator Co.
Sinko Tool & Mfg. Co.
Sobenite, Inc.
Standard Plastics Co.
Sterling Plastics Co.
Stokes Rubber Co., Jos.
Superior Plastic Co.
Thermo-Plastics, Inc.
Tilton-Cook Co.
United Comb & Novelty Co.
U. S. Plastic Corp.
Universal Plastics Corp.
Victory Molding Co.
Ward Plastic & Rubber Co.
White Dental Mfg. Co., S. S., Ind. Div.
Ziwel Plastics Corp.

LAMINATORS

Brandywine Fiber Prods. Co.
Continental-Diamond Fibre Co.
Detroit Paper Products Corp.
Formica Insulation Company
Franklin-Fibre-Lamitex Corp.
General Electric Co., Plastics Dept.
General Laminated Products, Inc.
Haskelite Mfg. Corp.
Masonite Corp.
Mica Insulator Co.
Micarta Fabricators of Illinois
National Vulcanized Fibre Co.
Panelyte Corp.
Parkwood Corp. (Woven Veneers)
Richardson Co.
Spaulding Fibre Co., Inc.
Synthane Corp.
Taylor Fibre Co.
Westinghouse Elec. & Mfg. Co., Micarta Div.
Wilmington Fibre & Specialty Company

MODEL MAKERS

Abel, Frank J.
Brigham, Richard B.
Dayton Insulating Molding Co.
Deveau Machine Tool Co., C. O.
Kunst Co., The, John
Sterling Plastics Co.
Stricker-Brunhuber Corp.

Addresses of companies listed appear on pages 449–452, this section

MOLDERS' MARKINGS

Accurate Molding Corp., Brooklyn, N. Y.

Accurate Molding Corp., Brooklyn, N. Y.

The Ackerman Rubber & Plastic Molding Company, Cleveland, Ohio

Advance Molding Corp., New York, N. Y.

Alden Products Corp. Brockton, Mass.

Allied Plastics Corp., Los Angeles, Cal.

American Hard Rubber Co., Butler, N. J.

American Insulator Corp., New Freedom, Pa.

American Molding Co., San Francisco, Cal.

American Phenolic Corp., Chicago, Ill.

Anchor Cap & Closure Corporation, Long Island City, New York

Armstrong Cork Products Company, Lancaster, Pa.

The Arrow-Hart & Hegeman Electric Co., Hartford, Conn.

Associated Attleboro Mfrs., Inc., Attleboro, Mass.

Atlantic Plastics, Cleveland, Ohio

Auburn Button Works, Auburn, N. Y.

Bay Manufacturing Company Division of Electric Auto-Lite Company, Bay City, Michigan

Belmont Molded Plastics Inc., Cincinnati, Ohio

Geo. F. Berkander, Providence, R. I.

Boonton Molding Co., Boonton, N. J.

Bridgeport Moulded Products, Inc., Bridgeport, Conn.

Bryant Electric Co., Bridgeport, Conn.

Chicago Molded Products Corp., Chicago, Ill.

Cincinnati Molding Co., Cincinnati, Ohio

Colt's Patent Fire Arms Mfg., Co., Hartford, Conn.

Consolidated Molded Products Corp., Scranton, Pa.

Cutler-Hammer, Inc., Milwaukee, Wisconsin

Cruver Manufacturing Co., Inc., Chicago, Ill.

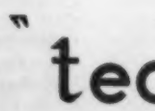
Dalmo Manufacturing Co., San Francisco, Cal.

Harry Davies Molding Co., Chicago, Ill.

Dayton Insulating Molding Co., Dayton, Ohio

Diemolding Corp., Canastota, N. Y.

Eclipse Moulded Products Company, Milwaukee, Wis.



The Emeloid Co., Inc., Arlington, N. J.

Erie Resistor Corp., Erie, Pa.

MOLDERS' MARKINGS

Firestone Tire & Rubber Company, Akron, Ohio

Garfield Mfg. Co., Garfield, N. J.

General Electric Co., Pittsfield, Mass.

General Industries, Inc., Elyria, Ohio

General Molding Co., Rockledge, Pa.

Gits Molding Corporation, Chicago, Ill.

Gorham Company Providence, R. I.

The Grigoleit Co., Decatur, Ill.

Wm. Gulliksen Machinary Co., Newton Lower Falls, Mass.

Harry W. Hahn Mfg. Co., Los Angeles, Cal.

Imperial Molded Products Co., Chicago, Ill.

Industrial Molded Products Co., Chicago, Ill.

Ingersoll-Rand Co., New York, N. Y.

Insulation Manufacturing Co., Inc., Brooklyn, N. Y.

Insulation Manufacturing Co. Inc., Brooklyn, N. Y.

International Molded Plastics, Inc., Cleveland, Ohio

H. Jamison, New York, N. Y.

Kessbey & Mattison Co., Ambler, Pa.

Kellogg Switchboard and Supply Co., Chicago, Ill.

Kuhn and Jacob Moulding & Tool Co., Trenton, N. J.

Kurz-Kasch, Inc., Dayton, Ohio

Mack Molding Co., Inc., Wayne, N. J.

Martindell Molding Co. Trenton, N. J.

The Thomas Mason Co., Inc. Stamford, Conn.

McDonald Mfg. Co., Los Angeles, Cal.

Mechanical Die & Tool Co., Brooklyn, N. Y.

Mico, Inc., Millerton, N. Y.

Midwest Molding & Mfg. Co., Chicago, Ill.

Elmer E. Mills Corporation, Chicago, Ill.

Modern Plastics Corp., Benton Harbor, Mich.

Molded Insulation Co., Philadelphia, Pa.

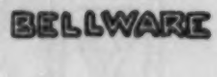
Molding Corp. of America, Providence, R. I.

National Lock Co. Rockford, Ill.

National Plastics, Inc., Knoxville, Tenn.

Northern Industrial Chemical Co., S. Boston, Mass.

MOLDERS' MARKINGS



Bell Mfg. Co., Division of Northern Industrial Chemical Co., S. Boston, Mass.

Norton Laboratories, Lockport, N. Y.

Oris Mfg. Co., Thomaston, Conn.

Owens-Illinois Glass Company, Toledo, Ohio

The Panelyte Corp., New York, N. Y.

Peerless Molded Plastics, Inc., Toledo, Ohio

Plastic Molding Corp., Cincinnati, Ohio

Plastic Molding Corporation, Sandy Hook, Conn.

Plastics, Inc., Bradley Beach, N. J.

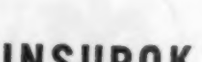
Recto Molded Products Co., Cincinnati, O.

F. E. Reinhold Co., Los Angeles, Cal.

Reynolds Molded Plastics Division of Reynolds Spring Co., Jackson, Michigan

Reynolds Spring Co. Jackson, Mich.

Reynolds Spring Co., Jackson, Mich.



The Richardson Co., Melrose Park, Chicago, Ill.

The Richardson Co., Melrose Park, Chicago, Ill.

Royal Molding Co., Providence, R. I.

Shaw Insulator Co., Irvington, N. J.

Shaw Insulator Co., Irvington, N. J.

Sinko Tool & Mfg. Co., Chicago, Ill.

Specialty Insulation Mfg. Co., Inc., Hoosick Falls, N. Y.

Standard Cap & Molding Co., Baltimore, Md.

Jos. Stokes Rubber Co., Trenton, N. J.

Synthetic Moulded Products, Inc., Stonington, Conn.

Tech-Art Plastics Co., Long Island City, N. Y.

Terkelsen Machine Co. Boston, Mass.

Union Insulating Co., Parkersburg, W. Va.

Universal Molding Co., San Francisco, Cal.

Universal Plastics Corp., New Brunswick, N. J.

Ward Plastic & Rubber Co., Ferndale, Mich.

Waterbury Button Co., Waterbury, Conn.

Watertown Mfg. Co., Watertown, Conn.

Westinghouse Elec. & Mfg. Co., Trafford, Pa.

Wheeling Stamping Co., Wheeling, W. Va.

Windman Brothers, Los Angeles, California

Ziwel Plastics Corp., Dover, Ohio

DIRECTORY OF TRADE NAMES

AND MANUFACTURERS OF PLASTICS LISTED IN PROPERTIES CHART

Phenol-Formaldehyde Molding Compounds

Bakelite	Bakelite Corp., 247 Park Ave., New York
Catalin	Catalin Corp., 1 Park Ave., New York
Celeron	Continental Diamond Fibre Co., Newark, Del. N. Y. office: 230 Park Ave.
Durez	Durez Plastics & Chemicals, Inc., 710 E. Walck Rd., N. Tonawanda, N. Y. N. Y. office: 250 Park Ave.
Durite	Durite Plastics, 5010 Summerdale Ave. (near Roosevelt Blvd.), Philadelphia, Pa.
Heresite	Heresite and Chemical Co., 822 S. 14th St., Manitowoc, Wis.
Indur	Reilly Tar & Chemical Corp., 500 Fifth Ave., New York, N. Y.
Insurok	Richardson Co., 2707 Lake St., Melrose Park (Chicago), Ill. N. Y. office: 75 West St.
Makalot	Makalot Corp., 262 Washington St., Boston, Mass.
Neillite	Watertown Mfg. Co., Watertown, Conn.
Resinox	Resinox Corp., Sub. Monsanto Chemical Co., 30 Rockefeller Pl., N. Y. C.
Textolite	General Electric Co., Plastics Dept., 1 Plastics Ave., Pittsfield, Mass.
Uniplast	Universal Plastics Co., 235 Jersey Ave., New Brunswick, N. J.

Phenol-Formaldehyde Laminated Products

Aqualite	National Vulcanized Fibre Co., Wilmington, Del.
Celeron	Continental Diamond Fibre Co., Newark, Del. N. Y. office: 230 Park Ave
Dilecto	Do.
Duraloy	Detroit Paper Products Corp., 5800 Domine St., Detroit, Mich.
Formica	Formica Insulation Co., 4672 Spring Grove Ave., Cincinnati, Ohio N. Y. office: 101 Park Ave.
Insurok	Richardson Co., 2707 Lake St., Melrose Park (Chicago), Ill. N. Y. office: 75 West St.
Lamicoid	Mica Insulator Co., 200 Varick St., New York, N. Y.
Micarta	Westinghouse Electric & Mfg. Co., Micarta Div., Trafford, Pa.
Ohmoid	Wilmington Fibre Specialty Co., East Wilmington, Del.
Panelyte	Panelyte Corp., 230 Park Ave., New York
Phenolite	National Vulcanized Fibre Co., Wilmington, Del.
Spauldite	Spaulding Fibre Co., 313 Wheeler St., Tonawanda, N. Y. N. Y. office: 484 Broome St.
Synthane	Synthane Corp., Oaks, Pa.
Taylor	Taylor Fibre Co., Norristown, Pa. N. Y. office: 90 West St.
Textolite	General Electric Co., Plastics Dept., 1 Plastics Ave., Pittsfield, Mass.
Ucinite	United-Carr Fastener Corp., 31 Ames St., Cambridge, Mass.

Phenol-Formaldehyde Cast Resins

Bakelite	Bakelite Corp., 247 Park Ave., New York
Catalin	Catalin Corp., 1 Park Ave., New York
Gemstone	A. Knoedler Co., Lancaster, Pa.
Marblette	Marblette Corp., 37-21 30th St., Long Island City, N. Y.
Monsanto C.P.	Plastics Div., Monsanto Chemical Co., Springfield, Mass. N. Y. office: 30 Rockefeller Plaza

Phenol-Furfural Resins

Durite	Durite Plastics, 5010 Summerdale Ave. (near Roosevelt Blvd.), Philadelphia, Pa.

Urea-Formaldehyde Molding Compounds

Bakelite	Bakelite Corp., 247 Park Ave., New York
Beetle	Beetle Products Div., American Cyanamid Co., 30 Rockefeller Pl., New York
Plaskon	Plaskon Co., Inc., 2112 Sylvan Ave., Toledo, Ohio N. Y. office: 41 E. 42nd St.

Urea-Formaldehyde Laminated Products

Beetle	Beetle Products Div., American Cyanamid Co., 30 Rockefeller Pl., New York
Formica	Formica Insulation Co., 4671 Spring Grove Ave., Cincinnati, Ohio
Insurok	Richardson Co., 2707 Lake St., Melrose Park (Chicago), Ill.
Micarta	Westinghouse Electric & Mfg. Co., Micarta Div., Trafford, Pa.

Aniline-Formaldehyde Resin

Cibanite	Ciba Co., Inc., 627 Greenwich, N. Y. C.

Vinyl Resins

Alvar	Shawinigan Products Corp., 350 Fifth Ave. New York, N. Y.
Butacite	E. I. du Pont de Nemours & Co., Inc., 10th and Market Sts., Wilmington, Del.
Butvar.	Shawinigan Prods. Co., 350 5th Ave., N. Y. C.
Formvar	Do.
Geiva	Do.
Vinylite	Carbide & Carbon Chemicals Corp., 30 E. 42nd St., New York, N. Y.

Acrylate and Methacrylate Resins

Crystalite	(Molding compound)	Röhm & Haas Co., Inc., 222 W. Washington Square, Philadelphia
Lucite	(Molding compound & cast resin)	E. I. du Pont de Nemours & Co., Inc., Plastics Dept., 626 Schuyler Ave., Arlington, N. J. N. Y. office: 350 Fifth Ave.
Plexiglas	(Cast resin)	Röhm & Haas Co., Inc., 222 W. Washington Square, Philadelphia

Styrene Resins

Bakelite	Bakelite Corp., 247 Park Ave., New York
Styron	Dow Chemical Co., Midland, Mich.

Shellac Compounds

Compo-Site	Compo-Site, Inc., 207 Astor St., Newark, N. J.
Harvite	Siemon Co., Bridgeport, Conn. N. Y. office: 145 Varick St.
Lacanite	Consolidated Molded Products Corp., 1938 Modern St., Scranton, Pa. N. Y. office: 1776 B'way.
———	T. F. Butterfield, Inc., 58 Rubber St., Naugatuck, Conn. N. Y. office: 303 Fifth Ave.
———	Waterbury Button Co., Waterbury, Conn. N. Y. office: 1133 B'way.

Cold Molded—Bituminous Type (Non-Refractory)

Aico	American Insulator Corp., New Freedom, Pa. N. Y. office: 101 Park Ave.
Amarine (phenolic)	Do.
Catec-Non-Refractory	General Electric Co., Plastics Dept., 1 Plastics Ave., Pittsfield, Mass.
Ebrok	Richardson Co., 2707 Lake St., Melrose Park (Chicago), Ill. N. Y. office: 75 West St.
Gummon	Garfield Mfg. Co., Wallington Rd., Garfield, N. J.
Okon	American Hard Rubber Co., 11 Mercer St., New York
Thermoplex	Cutler-Hammer, Inc., 1333 W. St. Paul Ave., Milwaukee, Wis. N. Y. office: 8 W. 40th St.

Cold Molded—Ceramic Type (Refractory)

Aico -5	American Insulator Corp., New Freedom, Pa.
Alphide	Standard Plastics Corp., 106 B'way, Jersey City, N. J.
Catec-Refractory	General Electric Co., Plastics Dept., 1 Plastics Ave., Pittsfield, Mass.
Coltstone	Colt's Patent Fire Arms Mfg. Co., 1935 Van Dyke Ave., Hartford, Conn. N. Y. office: 20 Vesey St.
Hemit	Garfield Mfg. Co., Wallington Rd., Garfield, N. J.

Rubber Derivatives and Rubber-like Resins

Amerite	Aqueous dispersion	American Anode, Inc., Akron, Ohio
Corprene	Synthetic rubber with ground cork	Armstrong Cork Products Co., Liberty St., Lancaster, Pa.
Flamenol	Vinyl chloride resin	General Electric Co., 1 River Rd., Schenectady, N. Y.
Kogene	Synthetic elastic	B. F. Goodrich Co., 454 S. Main St., Akron, Ohio
Koroseal	Vinyl chloride resin	Do.
Marbo	Chlorinated rubber	Marbo Products Corp., 469 E. Ohio St., Chicago, Ill.
Marbon	Do.	Do.
Neoprene	Chloroprene	E. I. du Pont de Nemours & Co., Inc., 10th and Market Sts., Wilmington, Del. N. Y. office: 350 Fifth Ave.
Pliofilm	Rubber hydrochloride	Goodyear Tire & Rubber Co., Inc., 1400 Cartwright St., Akron, Ohio N. Y. office: 600 W. 58th St.
Plioform	Modified isomerized rubber	Do.
Pliolite	Do.	Do.
Resistoflex PVA	Polyvinyl alcohol tubing	Resistoflex Corp., Dover, N. J.
Thiokol	Organic polysulfide	Thiokol Corp., 780 N. Clinton Ave., Trenton N. J.
Tornesit	Chlorinated rubber	Hercules Powder Co., 999 Market St., Wilmington, Del. N. Y. office: 20 E. 40th St.

Hard Rubber

Ace	American Hard Rubber Co., 11 Mercer St., New York, N. Y.
Luzerne	Luzerne Rubber Co., Dewey St., Trenton, N. J.
Rub-tex	Richardson Co., 2707 Lake St., Melrose Park (Chicago), Ill. N. Y. office: 75 West St.
———	Joseph Stokes Rubber Co., 322 Webster St., Trenton, N. J.
———	Vulcanized Rubber Co., 2 E. 29th St. New York, N. Y.

Casein

Ameroid	American Plastics Corp., 50 Union Square New York, N. Y.
Gala	George Morrell Corp., Muskegon Hts., Mich.
Galorn	Do.

Ethylcellulose

Ethocel	Dow Chemical Co., 919 Jefferson Ave. Midland, Mich.
———	Hercules Powder Co., 999 Market St. Wilmington, Del. N. Y. office: 20 E. 40th St.

Cellulose Acetate

Bakelite	Bakelite Corp., 247 Park Ave., New York
Lumarith	Celluloid Corp., 10 E. 40th St., New York, N. Y.
Masuron	John W. Masury & Son, 50 Jay St., Brooklyn N. Y.
Monsanto C.A.	Plastics Div., Monsanto Chemical Co., Springfield, Mass. N. Y. office: 30 Rockefeller Plaza
Nixonite	Nixon Nitration Works, Nixon, N. J.
Plastacele	E. I. du Pont de Nemours & Co., Inc., Plastics Dept., 626 Schuyler Ave., Arlington, N. J. N. Y. office: 350 Fifth Ave.
Tenite	Tennessee Eastman Corp., Kingsport, Tenn N. Y. office: Room 4105, 10 E. 40th St.
———	Hercules Powder Co., 999 Market St., Wilmington, Del.

Cellulose Acetate Butyrate

Tenite II	Tennessee Eastman Corp., Kingsport, Tenn.

Cellulose Nitrate (Pyroxylin)

Celluloid	Celluloid Corp., 10 E. 40th St., New York, N. Y.
Monsanto C.N.	Plastics Div., Monsanto Chemical Co., Springfield, Mass. N. Y. office: 30 Rockefeller Plaza
Nixonoid	Nixon Nitration Works, Nixon, N. J.
Pyralin	E. I. du Pont de Nemours & Co., Inc., Plastics Dept., 626 Schuyler Ave., Arlington, N. J. N. Y. office: 350 Fifth Ave.

Coumarone-Indene Resins

Cumar	Barrett Co., 40 Rector St., New York, N. Y.
Neville Resin	Neville Co., Neville Island Post Office, Pittsburgh, Pa.
Nevindene	Do

Lignin Plastics

Benaloid	Uncured lignin sheets	Masonite Corp., Laurel Miss.
Benalite	Cured lignin sheets	Do.

Varnish and Lacquer Resins

Trade Name	Composition	Manufacturer
Abalyn	Methyl abietate	Hercules Powder Co., 999 Market St., Wilmington, Del.
Acryloid	Acrylic	Resinous Products & Chemical Co., Inc., 222 W. Washington Square, Philadelphia
Acryseal	Do.	Do.
Aero Ester Gum	Rosin-glycerol	American Cyanamid Co., 30 Rockefeller Pl., New York, N. Y.
Aroo	Phenolic	Do.
Amberlac	Alkyd	Resinous Products & Chemical Co., Inc., 222 W. Washington Square, Philadelphia
Amberlite	Laminating phenolic	Do.
Amberol	Phenolic	Do.
Aquaplex	Alkyd emulsion	Do.
Aroclor	Chlorinated diphenyl	Monsanto Chemical Co., 1700 S. 2nd St., St. Louis, Mo.
Bakelite	Phenolic	Bakelite Corp., 247 Park Ave., New York
Beckacite	Modified phenolic	Reichhold Chemicals, Inc., 601 Woodward Hts. Blvd., Detroit, Mich.
Beckamine	Urea-formaldehyde	Do.
Beckolin	Synthetic oil	Do.
Beckosol	Do.	Do.
Beckopol	Phenolated copal	Do.
Beetle	Urea-formaldehyde	Beetle Products Div., American Cyanamid Co., 30 Rockefeller Pl., New York, N. Y.
Dulux	Alkyd	E. I. du Pont de Nemours & Co., Inc., 10th and Market Sts., Wilmington, Del.
Duraplex	Alkyd	Resinous Products & Chemical Co., 222 W. Washington Square, Philadelphia, Pa.
Durez	Phenolic	Durez Plastics & Chemicals Inc., N. Tonawanda, N. Y.
Esterol	Alkyd	Paramet Chemical Corp., 1017 Forty-fourth Ave., Long Island City, N. Y.
G	Glycerol-phthalic anhydride	Makalot Corp., 262 Washington St., Boston, Mass.
Glyptal	Alkyd	General Electric Co., Bridgeport, Conn.
Hercolyn	Hydrogenated methyl abietate	Hercules Powder Co., 999 Market St., Wilmington, Del.
Imperial Ester	Rosin-glycerol	J. D. Lewis, Inc., 68 Traverse St., Providence, R. I.
Kopol	Esterified copals	Reichhold Chemicals, Inc., 601 Woodward Hts. Blvd., Detroit, Mich.
Lewisol	Alkyd and phenolic	J. D. Lewis, Inc., 68 Traverse St., Providence, R. I.
Makalot	Alkyd, phenolic, and urea-formaldehyde	Makalot Corp., 262 Washington St., Boston, Mass.
Mirasol	Alkyd	Carbogen Chem. Co., Garwood, N. J.
Paradura	Phenolic	Paramet Chemical Corp., 1017 Forty-fourth Ave., Long Island City, N. Y
Paramet Ester Gum	Rosin-glycerol	Do.
Paranol	Phenolic	Do.
Paraplex	Alkyd	Resinous Products & Chemical Co., 222 W. Washington Square, Philadelphia, Pa.
Petrex	Terpinene maleic anhydride	Hercules Powder Co., 999 Market St., Wilmington, Del.
Phenac	Phenolic	American Cyanamid Co., 30 Rockefeller Pl., New York, N. Y
Rauzene	Phenolic	U. S. Industrial Alcohol Co., 480 Frelinghuysen Ave., Newark, N. J.
Rauzene Ester	Rosin-glyceride	Do.
Rauzite	Urea-formaldehyde	Do.
Rauzone	Alkyd	Do.
Rezyl	Alkyd	American Cyanamid Co., 30 Rockefeller Pl., New York, N. Y.
Santolite	Toluene sulfonamid formaldehyde	Monsanto Chemical Co., 1700 S. 2nd St., St. Louis, Mo.
Staybelite	Hydrogenated rosin	Hercules Powder Co. 999 Market St., Wilmington, Del.
Super-Beckacite	Pure phenolic	Reichhold Chemicals, Inc., 601 Woodward Hts. Blvd., Detroit, Mich.
Teslac	Alkyd	American Cyanamid Co., 30 Rockefeller Pl., New York, N. Y.
Uformite	Laminating urea-formaldehyde resin	Resinous Products & Chemical Co., 222 W. Washington Square, Philadelphia, Pa.
Vinsol	Modified rosin	Hercules Powder Co., 999 Market St., Wilmington, Del.
Vinylite	Vinyl resin	Carbide & Carbon Chemicals Corp., 30 E. 42nd St., New York

Miscellaneous Plastics

Abopon	Boro-phosphate	Glyco Products Co., Inc., 148 Lafayette St., N. Y.
Acwalite	Pyroxylin	Celluloid Corp., 10 E. 40th St., New York
Adhesowax	Synthetic wax	Glyco Products Co., Inc., 148 Lafayette St., N. Y.
Ameroy	Pyroxylin	Celluloid Corp., 10 E. 40th St., New York
Amer-glo	Do.	Do.
Amerith	Do.	Do.
Aquaresin	Glycol borisborate	Glyco Products Co. Inc., 148 Lafayette St., N. Y.
Arcelite	Phenolic	Consolidated Molded Products Corp., 1938 Modern St., Scranton, Pa.
Art-Y-Zan	Pyroxylin	Celluloid Corp., 10 E. 40th St., New York
Beetleware	Urea moldings	Beetle Products Div., American Cyanamid Co., 30 Rockefeller Pl., New York, N. Y.
Bonnyware	Urea moldings	Reynolds Molded Plastics, Div., Reynolds Spring Co., Jackson, Mich.
Carterite	Resin - pulp molding compound	Dispersion Products, Needham Hts., Mass.
Celastic	Pyroxylin box toes	Celastic Corp., Arlington, N. J.
Cellanite	Phenolic laminated	Continental Diamond Fibre Co., Newark, Del.
Celeron	Phenolic impregnated fabric	Continental Diamond Fibre Co., Newark, Del.
Cellophane	Regenerated cellulose wrapping	E. I. du Pont de Nemours & Co., Inc., 10th and Market Sts., Wilmington, Del.
Cellulak	Shellac paper-laminated tubing	Continental Diamond Fibre Co., Newark, Del.
Cel-O-Glass	Acetate-coated wire screen	Acetol Products, Inc., New York, N. Y.
Chemow	Cellulose acetate	Celluloid Corp., 10 E. 40th St., New York
Cibanoid	Urea-formaldehyde resin	Do.
Clair de Lune	Cellulose acetate	Celluloid Corp., 10 E. 40th St., New York
Clearsite	Cellulose acetate containers	Hygienic Tube & Container Co., Newark, N. J.
Colasta	Phenolic, etc.	Specialty Insulation Mfg. Co., 55 Center Ave., Hoosick Falls, N. Y.
Colfite	Graphited laminate	Formica Insulation Co., Cincinnati, Ohio
Coltrock	Phenolic	Colt's Patent Fire Arms Mfg. Co., 1935 Van Dyke Ave., Hartford, Conn.
Crystalex	Methacrylate denture compound	Detroit Dental Mfg. Co., 6801 12 St., Detroit, Mich.
Ethocoil	Ethylcellulose film	Dow Chemical Co., Midland, Mich.
Fiberlac	Cellulose nitrate lacquer	Plastics Div., Monsanto Chem. Co., Springfield, Mass.
Flexoresin	Glycol and glyceryl phthalates	Glyco Products Co., 148 Lafayette St., New York
Flexowax	Synthetic wax	Do.
Gemloid	Pyroxylin and cellulose acetate	Gemloid Corp., 425 Fourth Ave., New York, N. Y.
Glycene	Alkyd denture	Bakelite Corp., 247 Park Ave., New York
H-Scale	Synthetic pearl essence	Celluloid Corp., 10 E. 40th St., New York
Halowax	Chlorinated naphthalenes	Halowax Corp., 247 Park Ave., New York
Haskelite	Plywood bonded with phenolic resin	Haskelite Mfg. Co., 208 W. Washington St., Chicago, Ill.
Haveg	Phenolic-asbestos	Haveg Corp., E. Newark, Del.
Hemcoware	Urea moldings	Bryant Electric Co., 1934 Weaver Ave., Bridgeport, Conn.
Hercose AP	Cellulose acetate propionate	Hercules Powder Co., 999 Market St., Wilmington, Del.
Herculoid	Cellulose nitrate	Do.
Hycoloid	Cellulose nitrate containers	Hygienic Tube & Container Co., Newark, N. J.
Hydroresin A	Water soluble resin	Glyco Products Co., 148 Lafayette St., New York
Insuloid	Acetate packaging material	American Products Mfg. Co., New Orleans, La.
Ivalew	Pyroxylin	Celluloid Corp., 10 E. 40th St., New York
Kodaloid	Cellulose nitrate	Eastman Kodak Co., Rochester, N. Y.
Kodapak	Cellulose acetate	Do.
Lauxite	Urea-formaldehyde- zinc chloride resin for plywood	I. F. Laucks, Inc., 116 S. Niagara St., Lockport, N. Y.
Lucitone	Methacrylate denture compound	L. D. Caulk Co., Milford, Del.
Lumarith Protectoid	Cellulose acetate packaging material	Celluloid Corp., 10 E. 40th St., New York
Luxene	Phenolic denture	Bakelite Corp., 247 Park Ave., New York
Maizite	Alcohol soluble protein	Prolamine Products, Inc., 100 E. 42nd St., New York
Melocol	Polyamide formaldehyde	Ciba Co., Inc., 627 Greenwich St., New York
Melopas	Do.	Do.
Micabond	Bonded mica	Continental Diamond Fibre Co., Newark, Del.
Micanite	Mica	Mica Insulator Co., 200 Varick St., New York
Micoid	Phenolic laminated	Do.
Nevillac	Phenol-Indene coumarone	Neville Co., Neville Island Post Office, Pittsburgh, Pa.
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Norbo	Phenolic resin	Bakelite Corp., 247 Park Ave., New York
Parkwood	Acetate - impregnated woven veneer	Parkwood Corp., Leominster, Mass.
Parkwood-Textolite	Phenolic- or urea-impregnated woven veneer	General Electric Co., Plastics Dept., 1 Plastics Ave., Pittsfield, Mass.
Plexiglas	Acrylic resin for laminated glass	Röhm & Haas Co., Inc., 222 W. Washington Square, Philadelphia
Primal	Acrylic resin for leather finishes	Röhm & Haas Co., Inc., 222 W. Washington Square, Philadelphia.
Protecto	Cellulose acetate box toe material	Celluloid Corp., 10 E. 40th St., New York, N. Y.
Proxyl	Pyroxylin denture	Lee S. Smith & Son Mfg. Co., 7325 Pa. Ave., Pittsburgh, Pa.
Prystal	Cast phenolic (clear)	Catalin Corp., 1 Park Ave., New York
Resisto	Pyroxylin box toe material	Celluloid Corp., 10 E. 40th St., New York
Resovin	Vinyl denture	S. S. White Dental Mfg. Co., 211 S. 12th St., Philadelphia, Pa.
Revolite	Cloth impregnated with phenolic resin	Zapon Div., Atlas Powder Co., Stamford Conn.
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Rheolan	Thermoplastic pitch-like solid	Glyco Products Co., 148 Lafayette St., New York
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Safety Samson	Cellulose acetate film base	Celluloid Corp., 10 E. 40th St., New York
Samson	Pyroxylin film base	Do.
Sundora	Cellulose acetate	E. I. du Pont de Nemours & Co. Inc., Plastics Dept., 626 Schuyler Ave., Arlington, N. J.
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Tec	Cellulose acetate	Tennessee Eastman Corp., Kingsport, Tenn.
Tego	Phenolic resin for plywood	Resinous Products & Chemical Co., 222 W. Washington Square, Philadelphia, Pa.
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